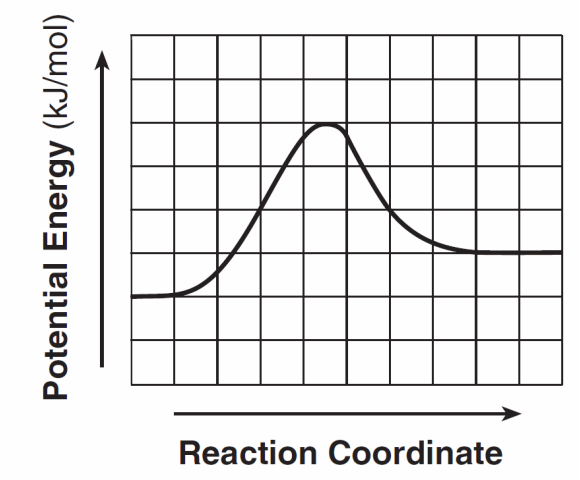
Name: **Kinetics & Equilibrium Review**

1. Given the potential energy diagram for a reversible chemical reaction:



Each interval on the axis labeled "Potential Energy (kJ/mol)" represents 10. kilojoules per mole. What is the activation energy of the forward reaction?

1) 10. kJ/mol
3) 40. kJ/mol
2) 30. kJ/mol
4) 60. kJ/mol

2. What is required for a chemical reaction to occur?

1) standard temperature and pressure
2) a catalyst added to the reaction system
3) effective collisions between reactant particles
4) an equal number of moles of reactants and products

3. 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.

4. Increasing the temperature increases the rate of a reaction by

1) lowering the activation energy
2) increasing the activation energy
3) lowering the frequency of effective collisions between reacting molecules
4) increasing the frequency of effective collisions between reacting molecules

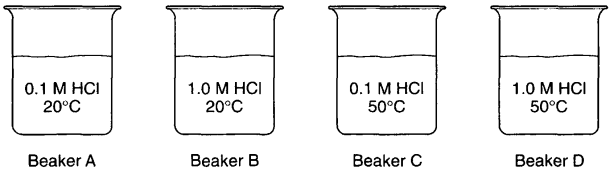
5. Given the reaction:

$$Mg + 2\ H_2O \rightarrow Mg(OH)_2 + H_2$$

At which temperature will the reaction occur at the greatest rate?

1) 25ºC
3) 75ºC
2) 50ºC
4) 100ºC

6. 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**

7. Given the reaction:

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

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

8. Given the balanced equation representing a reaction:

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

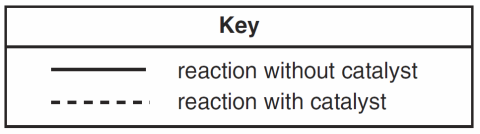
This reaction occurs more quickly when powdered iron is used instead of a single piece of iron of the same mass because the powdered iron

1) acts as a better catalyst than the single piece of iron
2) absorbs less energy than the single piece of iron
3) has a greater surface area than the single piece of iron
4) is more metallic than the single piece of iron

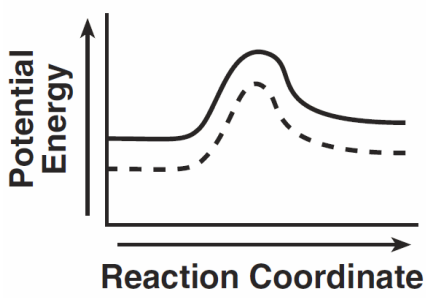
9. At STP, which 4.0-gram zinc sample will react fastest with dilute hydrochloric acid?

1) lump
3) powdered
2) bar
4) sheet metal

10. Which potential energy diagram represents the change in potential energy that occurs when a catalyst is added to a chemical reaction?



1)



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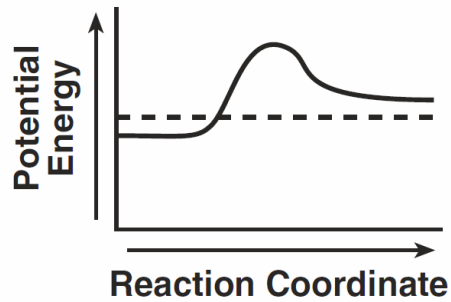

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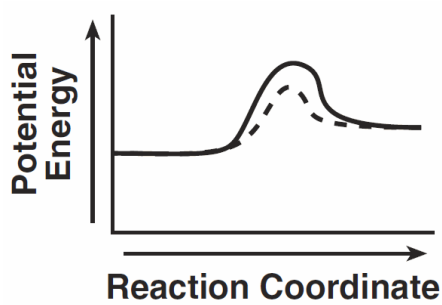
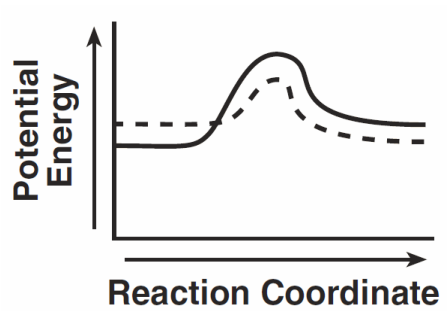


4)



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

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

12. For a given reaction, adding a catalyst increases the rate of the reaction by

1) providing an alternate reaction pathway that has a higher activation energy
2) providing an alternate reaction pathway that has a lower activation energy
3) using the same reaction pathway and increasing the activation energy
4) using the same reaction pathway and decreasing the activation energy

13. A thermometer is in a beaker of water. Which statement best explains why the thermometer reading initially increases when LiBr(s) is dissolved in the water?

1) The entropy of the LiBr(aq) is greater than the entropy of the water.
2) The entropy of the LiBr(aq) is less than the entropy of the water.
3) The dissolving of the LiBr(s) in water is an endothermic process.
4) The dissolving of the LiBr(s) in water is an exothermic process.

14. Which balanced equation represents an endothermic reaction?

1) $C(s) + O_2(g) \rightarrow CO_2(g)$
2) $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(\ell)$
3) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
4) $N_2(g) + O_2(g) \rightarrow 2NO(g)$

15. For a chemical reaction, the difference between the potential energy of the products and the potential energy of the reactants is equal to the

1) heat of fusion
2) heat of reaction
3) activation energy of the forward reaction
4) activation energy of the reverse reaction

16. Given the balanced equation representing a reaction at 101.3 kPa and 298 K:

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g) + 91.8$ kJ

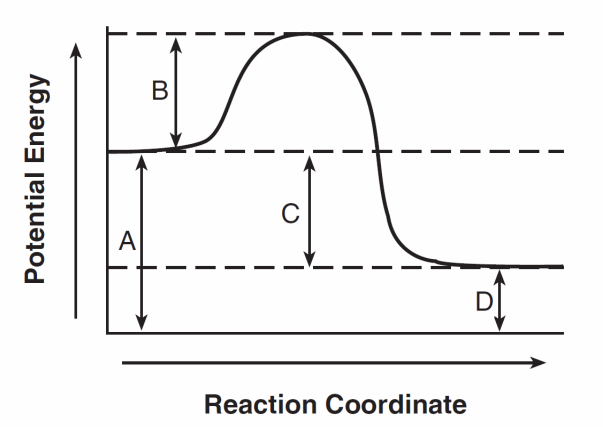
Which statement is true about this reaction?

1) It is exothermic and ΔH *equals –91.8 kJ.*
2) It is exothermic and ΔH *equals +91.8 kJ.*
3) It is endothermic and ΔH *equals –91.8 kJ.*
4) It is endothermic and ΔH *equals +91.8 kJ.*

17. According to Table *I*, which equation representsa change resulting in the greatest quantity of energy released?

1) $2C(s) + 3H_2(g) \rightarrow C_2H_6(g)$
2) $2C(s) + 2H_2(g) \rightarrow C_2H_4(g)$
3) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
4) $N_2(g_+O_2(g) \rightarrow 2NO(g)$

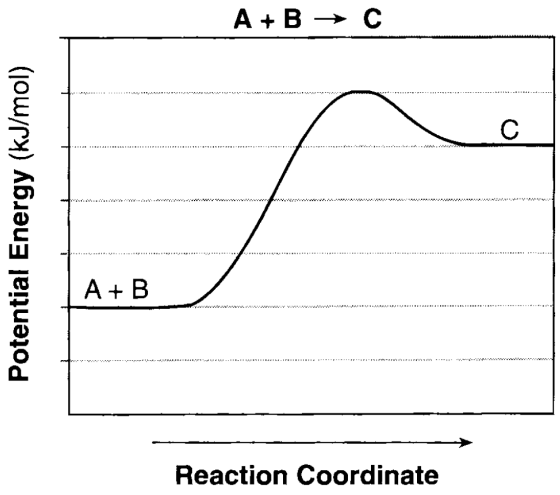
18. Given the potential energy diagram representing a reversible reaction:



The activation energy for the reverse reaction is represented by

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

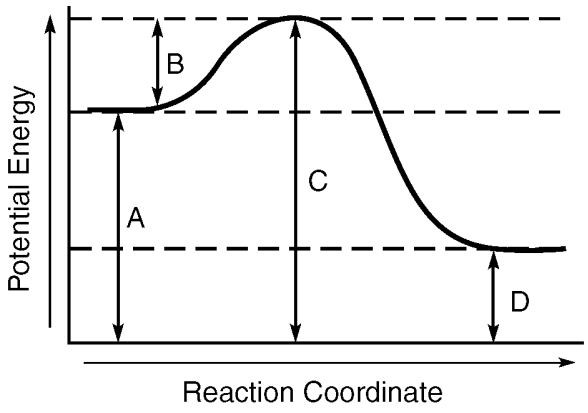
19. Given the equation and potential energy diagram representing a reaction:



If each interval on the axis labeled "Potential Energy (kJ/mol)" represents 10. kJ/mol, what is the heat of reaction?

1) +60. kJ/mol
3) +30. kJ/mol
2) +20. kJ/mol
4) +40. kJ/mol

20. The potential energy diagram below represents a reaction.



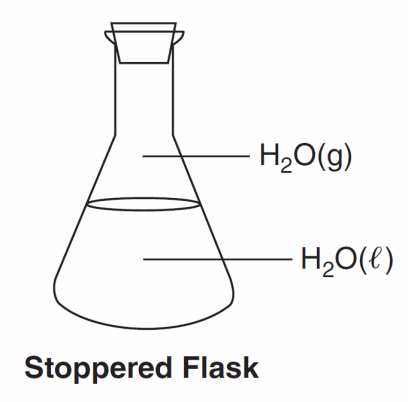
Which arrow represents the activation energy of the forward reaction?

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

21. Which statement describes a chemical reaction at equilibrium?

1) The products are completely consumed in the reaction.
2) The reactants are completely consumed in the reaction.
3) The concentrations of the products and reactants are equal.
4) The concentrations of the products and reactants are constant.

22. Given the diagram representing a closed system at constant temperature:



Stoppered Flask

Which statement describes this system at equilibrium?

1) The mass of $H_2O(\ell)$ equals the mass of $H_2O(g)$.
2) The volume of $H_2O(\ell)$ equals the volume of $H_2O(g)$.
3) The number of moles of $H_2O(\ell)$ equals the number of moles of $H_2O(g)$.
4) **The rate of evaporation of $H_2O(\ell)$ equals the rate of condensation of $H_2O(g)$.**

23. Which two factors must be equal when a chemical reaction reaches equilibrium?

1) the concentration of the reactants and the concentration of the products
2) the number of reactant particles and the number of product particles
3) **the rate of the forward reaction and the rate of the reverse reaction**
4) the mass of the reactants and the mass of the products

24. Some solid KNO_3 remains at the bottom of a stoppered flask containing a saturated $KNO_3(aq)$ solution at 22°C. Which statement explains why the contents of the flask are at equilibrium?

1) **The rate of dissolving is equal to the rate of crystallization.**
2) The rate of dissolving is greater than the rate of crystallization.
3) The concentration of the solid is equal to the concentration of the solution.
4) The concentration of the solid is greater than the concentration of the solution.

25. Given the equation representing a system at equilibrium:

H_2O (s) $\leftrightarrow$ H_20 (l)
At which temperature does this equilibrium exist at 101.3 kilopascals?

1) 0 K
2) **0°C**
3) 32 K
4) 273°C

26. 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) increasing the temperature
2) **increasing the pressure**
3) decreasing the amount of $SO_2(g)$
4) decreasing the amount of $O_2(g)$

27. 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 $A_2B_3(g)$?

1) adding more $A(g)$
2) **adding a catalyst**
3) increasing the temperature
4) increasing the pressure

28. Given the equation representing a reaction at equilibrium:

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

Which change causes the equilibrium to shift to the right?

1) adding a catalyst
2) **adding more $O_2(g)$**
3) decreasing the pressure
4) increasing the temperature

29. Given the equation representing a system at equilibrium:

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

Which changes occur when the temperature of this system is *decreased*?

1) The concentration of $H_2(g)$ increases and the concentration of $N_2(g)$ increases.
2) The concentration of $H_2(g)$ decreases and the concentration of $N_2(g)$ increases.
3) The concentration of $H_2(g)$ decreases and the concentration of $NH_3(g)$ decreases.
4) **The concentration of $H_2(g)$ decreases and the concentration of $NH_3(g)$ increases.**

30. In terms of entropy and energy, systems in nature tend to undergo changes toward

1) lower entropy and lower energy
2) lower entropy and higher energy
3) **higher entropy and lower energy**
4) higher entropy and higher energy

31. Which equation represents a change that results in an increase in disorder?

1) **$I_2(s) \rightarrow I_2(g)$**
2) $CO_2(g) \rightarrow CO_2(s)$
3) $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$
4) $2H_2(g) + O_2(g) \rightarrow 2H_2O(\ell)$

Base your answers to questions **32** through **34** on the information below and on your knowledge of chemistry.

Common household bleach is an aqueous solution containing hypochlorite ions. A closed container of bleach is an equilibrium system represented by the equation below.

$$Cl_2(g) + 2OH^-(aq) \rightleftharpoons ClO^-(aq) + Cl^-(aq) + H_2O(\ell)$$

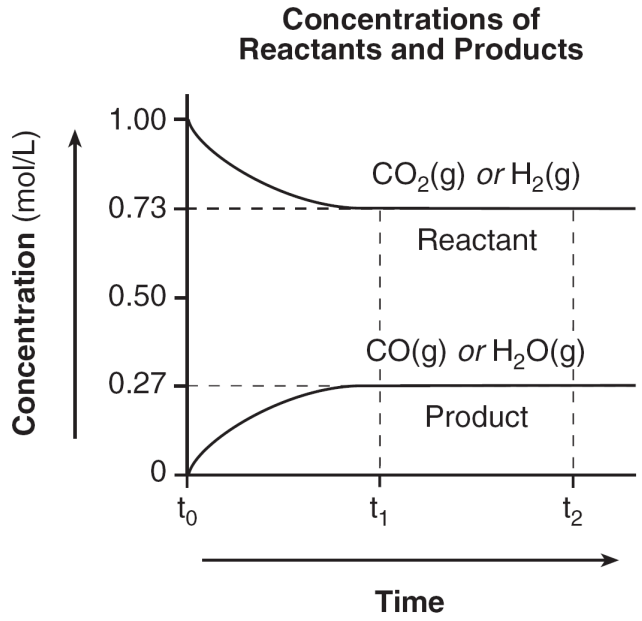
32. State the effect on the concentration of the ClO^- ion when there is a *decrease* in the concentration of the OH^- ion.

33. Explain why the container must be closed to maintain equilibrium.

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

Base your answers to questions **35** and **36** on the information below.

At 550°C, 1.00 mole of $CO_2(g)$ and 1.00 mole of $H_2(g)$ are placed in a 1.00-liter reaction vessel. The substances react to form CO(g) and $H_2O(g)$. Changes in the concentrations of the reactants and the concentrations of the products are shown in the graph below.

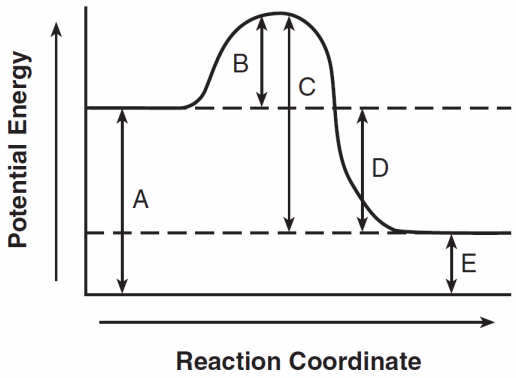


35. What can be concluded from the graph about the concentrations of the reactants and the concentrations of the products between time t_1 and time t_2?

36. Determine the change in the concentration of $CO_2(g)$ between time t_0 and time t_1.

Base your answers to questions **37** and **38** on the information below.

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



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

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

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

Base your answers to questions **39** and **40** 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

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

40. State how increasing the number of drops of 0.02 M $KIO_3(aq)$ used in the reaction affects the rate of reaction.

Answer Key

Kinetics Equilibrium Review

1. 3
2. 3
3. 3
4. 4
5. 4
6. 4
7. 4
8. 3
9. 3
10. 2
11. 1
12. 2
13. 4
14. 4
15. 2
16. 1
17. 3
18. 2
19. 3
20. 2
21. 4
22. 4
23. 3
24. 1
25. 2
26. 2
27. 2
28. 2
29. 4
30. 3
31. 1
32. – The concentration of the ClO^- ion decreases. – $[ClO^-]$ decreases. – lower ClO^- concentration – less ClO^-
33. – The container must be closed so that no matter can enter or leave, thus distributing the equilbrium. – If the container is open, Cl_2 gas escapes. – to keep the concentration of the reactants and products constant
34. – The rate of the forward reaction is equal to the rate of the reverse reaction. – They are the same. – equal
35. – Between time t_1 and time t_2, the concentrations of the reactants and the concentrations of the products are no longer changing. – The concentrations of the reactants and the products remain constant. – The concentration of each reactant is 0.73 mol/L, and the concentration of each product is 0.27 mol/L.
36. – –0.27 mol/L – 0.27 mol/L
37. 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.
38. *B*
39. the temperature of the reactants or a catalyst
40. –Increasing the number of drops of KIO_3(aq) increases the rate of reaction. –The reaction takes less time if more drops of KIO_3 are used. –The reaction occurs faster.