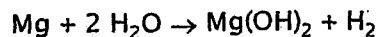


Thermodynamics and Kinetics Regents Review

1. 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
2. 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
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
- (1) ionization energy
 - (2) activation energy
 - (3) heat of reaction
 - (4) heat of vaporization
4. 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
5. In most aqueous reactions as temperature increases, the effectiveness of collisions between reacting particles
- (1) decreases
 - (2) increases
 - (3) remains the same
6. Given the reaction:

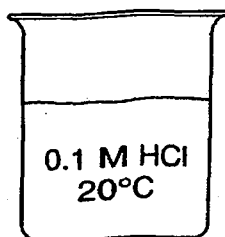


At which temperature will the reaction occur at the greatest rate?

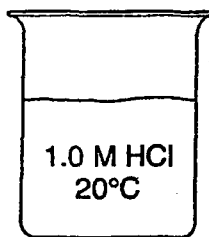
- (1) 25°C
- (2) 50°C
- (3) 75°C
- (4) 100°C

Thermodynamics and Kinetics Regents Review

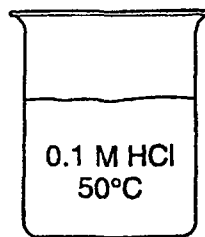
7. In each of the four beakers shown below, a 2.0-centimeter strip of magnesium ribbon reacts with 100 milliliters of HCl(aq) under the conditions shown.



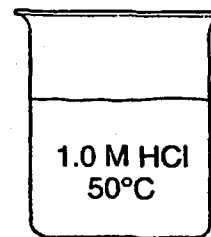
Beaker A



Beaker B



Beaker C



Beaker D

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

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

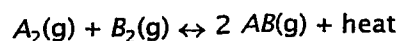
8. A 1.0-gram piece of zinc reacts with 5 milliliters of HCl(aq). Which of these conditions of concentration and temperature would produce the greatest rate of reaction?

- (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

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

- (1) decreases (3) remains the same
(2) increases

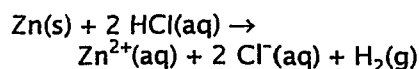
10. Given the reaction:



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 $B_2(g)$

11. Given the reaction:



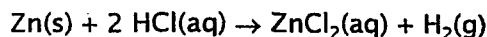
If the concentration of HCl(aq) is increased, the frequency of reacting collisions will

- (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

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

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

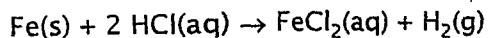
13. Given the reaction at 25°C:



The rate of this reaction can be increased by using 5.0 grams of powdered zinc instead of a 5.0-gram strip of zinc because the powdered zinc has

- (1) lower kinetic energy (3) more surface area
(2) lower concentration (4) more zinc atoms

14. Given the reaction:



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

15. 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

16. 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

Adding a catalyst to a chemical reaction results in

- (1) a decrease in activation energy and a decrease in the reaction rate
- (2) a decrease in activation energy and an increase in the reaction rate
- (3) an increase in activation energy and a decrease in the reaction rate
- (4) an increase in activation energy and an increase in the reaction rate

18. 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

19. 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.

20. Based on the nature of the reactants in each of the equations below, which reaction at 25°C will occur at the fastest rate?

- (1) $\text{C}(s) + \text{O}_2(g) \rightarrow \text{CO}_2(g)$
- (2) $\text{NaOH}(aq) + \text{HCl}(aq) \rightarrow \text{NaCl}(aq) + \text{H}_2\text{O}(l)$
- (3) $\text{CH}_3\text{OH}(l) + \text{CH}_3\text{COOH}(l) \rightarrow \text{CH}_3\text{COOCH}_3(aq) + \text{H}_2\text{O}(l)$
- (4) $\text{CaCO}_3(s) \rightarrow \text{CaO}(s) + \text{CO}_2(g)$

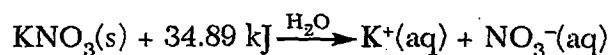
21. A catalyst is added to a system at equilibrium. If the temperature remains constant, the activation energy of the forward reaction

- (1) decreases
- (2) increases
- (3) remains the same

22. Adding a catalyst to a chemical reaction changes the rate of reaction by causing

- (1) a decrease in the activation energy
- (2) an increase in the activation energy
- (3) a decrease in the heat of reaction
- (4) an increase in the heat of reaction

23. Given the balanced equation:



Which statement best describes this process?

- (1) It is endothermic and entropy increases.
- (2) It is endothermic and entropy decreases.
- (3) It is exothermic and entropy increases.
- (4) It is exothermic and entropy decreases.

24. Which change is exothermic?

- (1) freezing of water
- (2) melting of iron
- (3) vaporization of ethanol
- (4) sublimation of iodine

25. 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
- (1) involved in the formation of an acidic solution
 - (2) involved in the formation of a basic solution
 - (3) an exothermic reaction
 - (4) an endothermic reaction

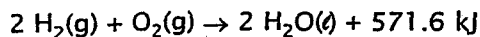
26. Salt A and salt B were each dissolved in separate beakers of water at 21°C. The temperature of the salt A solution decreased, and the temperature of the salt B solution increased.

Based on these results, which conclusion is correct?

- (1) The water gained energy from both salt A and salt B.
 - (2) The water lost energy to both salt A and salt B.
 - (3) The water gained energy from salt A and lost energy to salt B.
 - (4) The water lost energy to salt A and gained energy from salt B.
27. 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
- (1) is endothermic
 - (2) is exothermic
 - (3) produces an acid solution
 - (4) produces a salt solution

28. Which statement correctly describes an endothermic chemical reaction?
- (1) The products have higher potential energy than the reactants, and the ΔH is negative.
 - (2) The products have higher potential energy than the reactants, and the ΔH is positive.
 - (3) The products have lower potential energy than the reactants, and the ΔH is negative.
 - (4) The products have lower potential energy than the reactants, and the ΔH is positive.

29. Given the reaction:

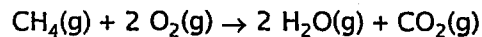


What is the approximate ΔH for the formation of 1 mole of $\text{H}_2\text{O}(\text{l})$?

- (1) -285.8 kJ
- (2) +285.8 kJ
- (3) -571.6 kJ
- (4) +571.6 kJ

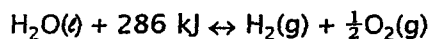
30. According to Table I, which salt releases energy as it dissolves?
- (1) KNO_3
 - (2) LiBr
 - (3) NH_4NO_3
 - (4) NaCl

31. Given the reaction:



What is the overall result when $\text{CH}_4(\text{g})$ burns according to this reaction?

- (1) Energy is absorbed and ΔH is negative.
 - (2) Energy is absorbed and ΔH is positive.
 - (3) Energy is released and ΔH is negative.
 - (4) Energy is released and ΔH is positive.
32. According to Reference Table I, which statement best describes the formation of $\text{HI}(\text{g})$?
- (1) It is exothermic, and heat is released.
 - (2) It is exothermic, and heat is absorbed.
 - (3) It is endothermic, and heat is released.
 - (4) It is endothermic, and heat is absorbed.
33. Which statement best describes a chemical reaction in which energy is released?
- (1) It is exothermic and has a negative ΔH .
 - (2) It is exothermic and has a positive ΔH .
 - (3) It is endothermic and has a negative ΔH .
 - (4) It is endothermic and has a positive ΔH .
34. Given the reaction:



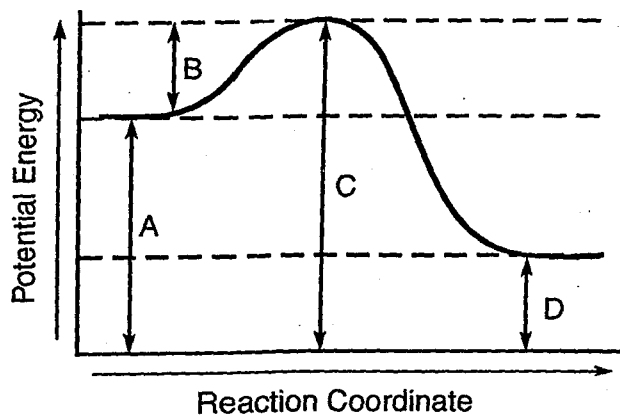
Which statement describes the reverse reaction?

- (1) It is endothermic and releases 286 kJ.
 - (2) It is endothermic and absorbs 286 kJ.
 - (3) It is exothermic and releases 286 kJ.
 - (4) It is exothermic and absorbs 286 kJ.
35. The heat energy (ΔH) absorbed or released during the formation of products is equal to
- (1) $(H_{\text{products}}) - (H_{\text{reactants}})$
 - (2) $(H_{\text{reactants}}) - (H_{\text{products}})$
 - (3) $(H_{\text{products}}) \times (H_{\text{reactants}})$
 - (4) $\frac{(H_{\text{products}})}{(H_{\text{reactants}})}$

36. Which information about a chemical reaction is provided by a potential energy diagram?

- (1) the oxidation states of the reactants and products
- (2) the average kinetic energy of the reactants and products
- (3) the change in solubility of the reacting substances
- (4) the energy released or absorbed during the reaction

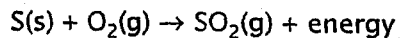
37. The potential energy diagram below represents a reaction.



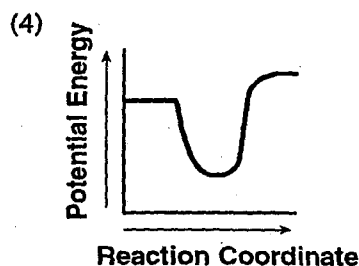
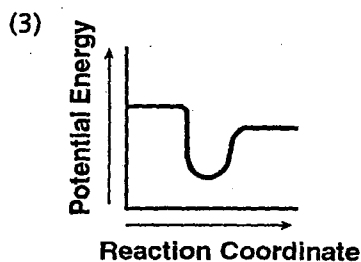
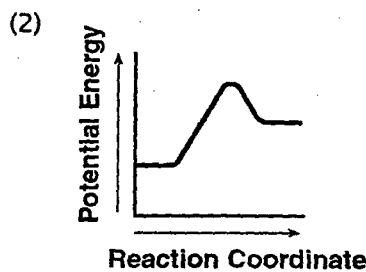
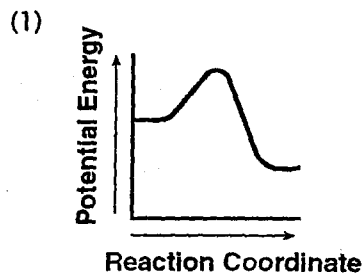
Which arrow represents the activation energy of the forward reaction?

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

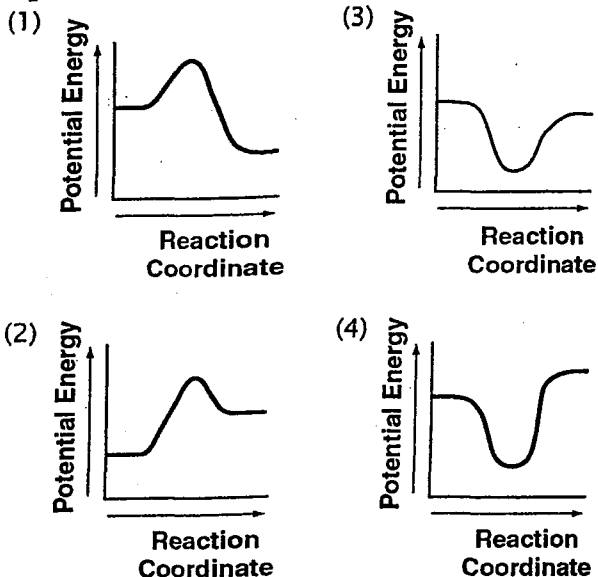
38. Given the reaction:



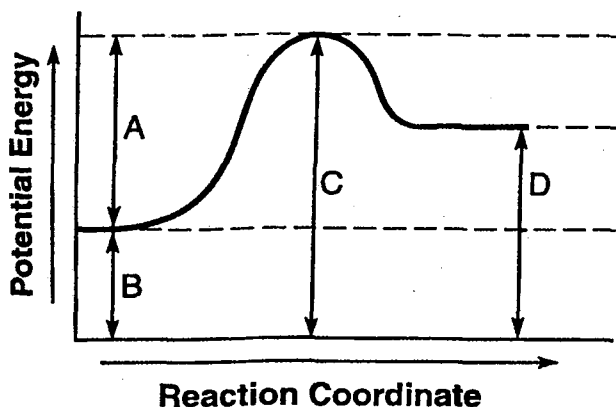
Which diagram best represents the potential energy changes for this reaction?



39. According to Table I, which potential energy diagram best represents the reaction that forms $H_2O(l)$ from its elements?



40. Given the potential energy diagram of a chemical reaction:



Which arrow represents the potential energy of the reactants?

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

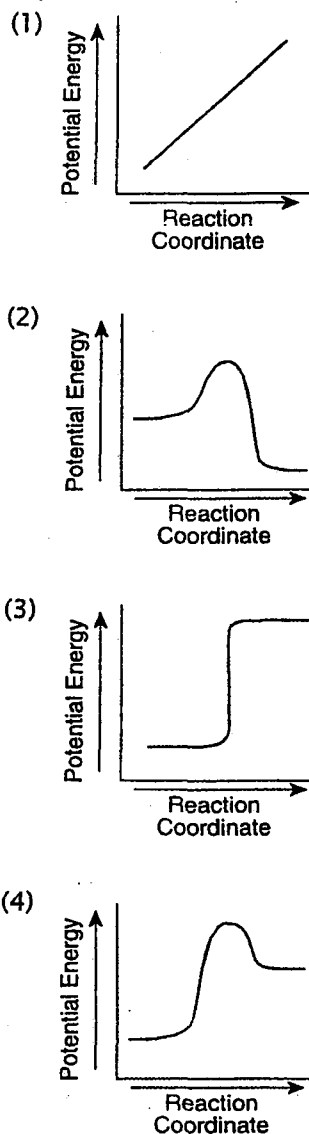
41. The activation energy required for a chemical reaction can be *decreased* by

- (1) increasing the surface area of the reactant
 (2) increasing the temperature of the reactant
 (3) adding a catalyst to the reaction
 (4) adding more reactant

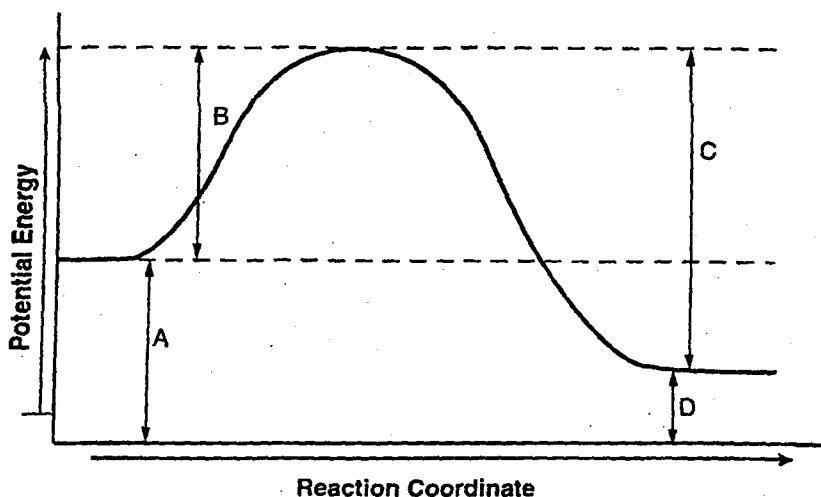
42. In a potential energy diagram, the difference between the potential energy of the products and the potential energy of the reaction is equal to the

- (1) heat of reaction
 (2) entropy of the reaction
 (3) activation energy of the forward reaction
 (4) activation energy of the reverse reaction

43. When a spark is applied to a mixture of hydrogen and oxygen, the gases react explosively. Which potential energy diagram best represents the reaction?



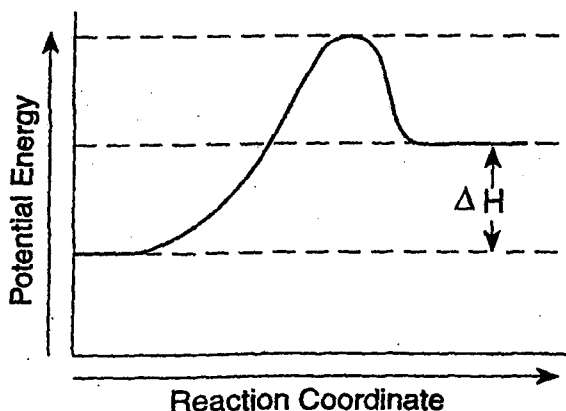
14. A potential energy diagram is shown below.



Which letters represent the activation energy of the forward and reverse reactions, respectively?

- (1) A and C (2) A and D (3) B and C (4) B and D

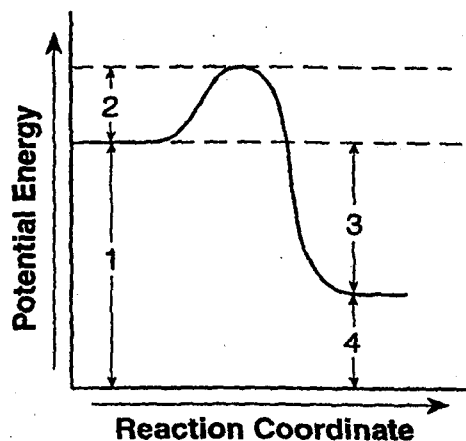
45. The diagram below represents the energy changes that occur during the formation of a certain compound under standard conditions.



According to Reference Table I, the compound could be

- (1) $C_2H_6(g)$
 (2) $CO_2(g)$
 (3) $HI(g)$
 (4) $NH_3(g)$

Base your answers to questions 46 and 47 on the potential energy diagram below, which represents the reaction:



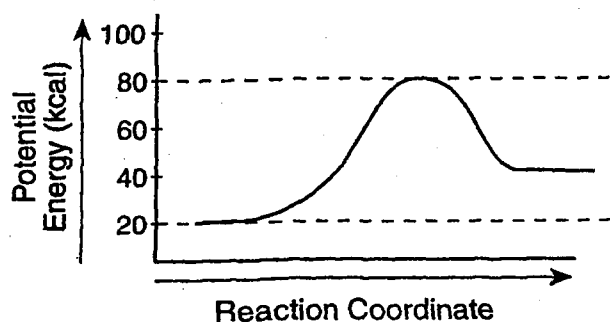
46. Which numbered interval will change with the addition of a catalyst to the system?

- (1) 1 (3) 3
 (2) 2 (4) 4

47. Which statement correctly describes this reaction?

- (1) It is endothermic and energy is absorbed.
 (2) It is endothermic and energy is released.
 (3) It is exothermic and energy is absorbed.
 (4) It is exothermic and energy is released.

48. A potential energy diagram of a chemical reaction is shown below.



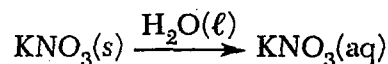
What is the difference between the potential energy of the reactants and the potential energy of the products?

- (1) 20. kcal (3) 60. kcal
 (2) 40. kcal (4) 80. kcal
49. At STP, a sample of which element has the highest entropy?
- (1) Na(s)
 (2) Hg(l)
 (3) Br₂(l)
 (4) F₂(g)
50. Systems in nature tend to undergo changes toward
- (1) lower energy and lower entropy
 (2) lower energy and higher entropy
 (3) higher energy and lower entropy
 (4) higher energy and higher entropy
51. Which of these changes produces the greatest increase in entropy?
- (1) CaCO₃(s) → CaO(s) + CO₂(g)
 (2) 2 Mg(s) + O₂(g) → 2 MgO(s)
 (3) H₂O(g) → H₂O(l)
 (4) CO₂(g) → CO₂(s)
52. Even though the process is endothermic, snow can sublime. Which tendency in nature accounts for this phase change?
- (1) a tendency toward greater entropy
 (2) a tendency toward greater energy
 (3) a tendency toward less entropy
 (4) a tendency toward less energy

53. Which 10-milliliter sample of water has the greatest degree of disorder?

- (1) H₂O(g) at 120°C
 (2) H₂O(l) at 80°C
 (3) H₂O(l) at 20°C
 (4) H₂O(s) at 0°C

54. Given the equation:



As H₂O(l) is added to KNO₃(s) to form KNO₃(aq), the entropy of the system

- (1) decreases (3) remains the same
 (2) increases
55. As carbon dioxide sublimes, its entropy
- (1) decreases (3) remains the same
 (2) increases
56. Which phase change represents a *decrease* in entropy?
- (1) solid to liquid (3) liquid to gas
 (2) gas to liquid (4) solid to gas
57. Which sample has the *lowest* entropy?
- (1) 1 mole of KNO₃(l)
 (2) 1 mole of KNO₃(s)
 (3) 1 mole of H₂O(l)
 (4) 1 mole of H₂O(g)
58. Which process is accompanied by a *decrease* in entropy?
- (1) boiling of water
 (2) condensing of water vapor
 (3) subliming of iodine
 (4) melting of ice
59. Which sample has the greatest entropy?
- (1) NH₃(g)
 (2) NH₃(l)
 (3) NH₃(s)
 (4) NH₃(aq)
60. Which reaction has the greatest increase in entropy?
- (1) 2 H₂O(l) → 2 H₂(g) + O₂(g)
 (2) 2 H₂O(g) → 2 H₂(g) + O₂(g)
 (3) H₂O(g) → H₂O(l)
 (4) H₂O(l) → H₂O(s)

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61. Which equation shows an increase in entropy?

- (1) $\text{CO}_2(\text{g}) \rightarrow \text{CO}_2(\text{s})$
 (2) $\text{CO}_2(\ell) \rightarrow \text{CO}_2(\text{g})$
 (3) $\text{CH}_3\text{OH}(\ell) \rightarrow \text{CH}_3\text{OH}(\text{s})$
 (4) $\text{CH}_3\text{OH}(\text{g}) \rightarrow \text{CH}_3\text{OH}(\ell)$

62. Which 1.0-mole sample at 1 atm has particles with the greatest entropy?

- (1) $\text{CH}_4(\text{g})$ at 25°C
 (2) $\text{H}_2\text{S}(\text{g})$ at 40°C
 (3) $\text{CH}_4(\text{g})$ at 300 K
 (4) $\text{H}_2\text{S}(\text{g})$ at 310 K

63. Under the same conditions of temperature and pressure, which sample contains particles having the *lowest* entropy?

- (1) $\text{CO}_2(\text{g})$
 (2) $\text{CO}_2(\ell)$
 (3) $\text{CO}_2(\text{s})$
 (4) $\text{CO}_2(\text{aq})$

64. Which change in a sample of water is accompanied by the greatest increase in entropy?

- (1) $\text{H}_2\text{O}(\ell)$ at 100°C is changed to $\text{H}_2\text{O}(\text{g})$ at 200°C .
 (2) $\text{H}_2\text{O}(\text{g})$ at 100°C is changed to $\text{H}_2\text{O}(\text{g})$ at 200°C .
 (3) $\text{H}_2\text{O}(\text{s})$ at -100°C is changed to $\text{H}_2\text{O}(\text{s})$ at 0°C .
 (4) $\text{H}_2\text{O}(\text{s})$ at -100°C is changed to $\text{H}_2\text{O}(\ell)$ at 0°C .

65. Which condition is necessary for a chemical reaction to occur spontaneously?

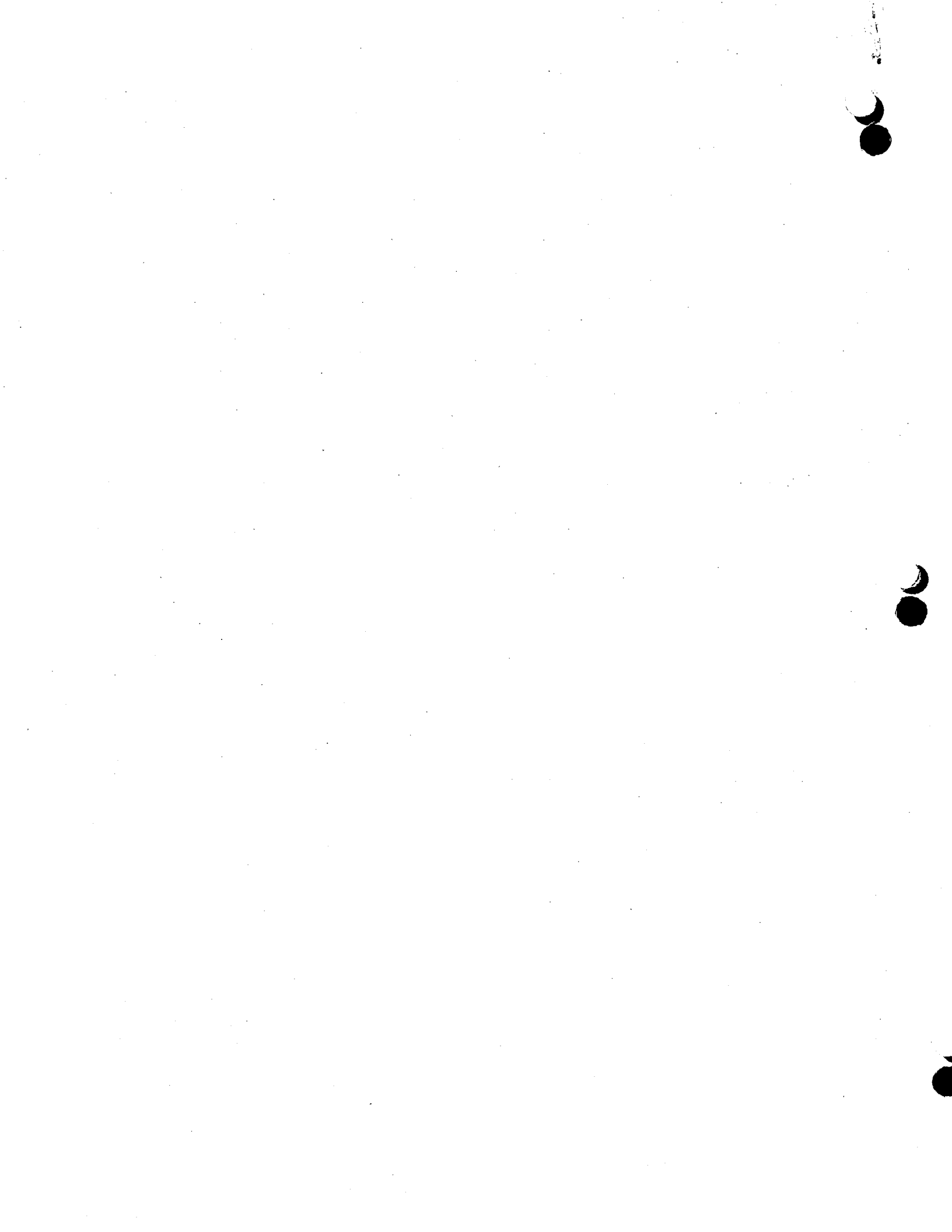
- (1) ΔS must be negative.
 (2) ΔS must be positive.
 (3) ΔG must be negative.
 (4) ΔG must be positive.

66. The change in the free energy of a reaction (ΔG) is equal to

- (1) $T\Delta H - \Delta S$ (3) $\Delta H - T\Delta S$
 (2) $T\Delta H + \Delta S$ (4) $\Delta H + T\Delta S$

67. Which compound forms spontaneously from its elements at 1 atm and 298 K?

- (1) $\text{C}_2\text{H}_2(\text{g})$
 (2) $\text{C}_2\text{H}_4(\text{g})$
 (3) $\text{HF}(\text{g})$
 (4) $\text{HI}(\text{g})$



Thermodynamics and Kinetics Regents Review
Answer Key

3. 3

30. 2

59. 1

4. 4

31. 3

60. 1

2. 2

32. 4

61. 2

1. 3

33. 1

62. 2

6. 2

34. 3

63. 3

5. 4

35. 1

64. 1

7. 4

36. 4

65. 3

8. 4

37. 2

66. 3

9. 2

38. 1

67. 3

10. 4

39. 1

11. 4

40. 2

12. 3

41. 3

13. 3

42. 1

14. 2

43. 2

15. 3

44. 3

16. 2

45. 3

17. 2

46. 2

18. 4

47. 4

19. 4

48. 1

20. 2

49. 4

21. 1

50. 2

22. 1

51. 1

23. 1

52. 1

24. 1

53. 1

25. 3

54. 2

26. 4

55. 2

27. 2

56. 2

28. 2

57. 2

29. 1

58. 2

