1. The following reaction

$$C(s) + CO_2(g) \rightarrow 2CO(g)$$

is spontaneous only at temperatures in excess of 1100 K. From this information, we can conclude that

a. $\Delta H^o > 0$ and $\Delta S^o < 0$
b. $\Delta H^o < 0$ and $\Delta S^o < 0$
c. $\Delta H^o > 0$ and $\Delta S^o > 0$
d. $\Delta H^o < 0$ and $\Delta S^o > 0$
e. $\Delta G^o < 0$ at all temperatures

2. Calculate ΔG^o of formation, in kJ/mol, for H_3PO_4.

$4P(s) + 5O_2(g) \rightarrow P_4O_{10}(s)$	$\Delta G° = -269.8$ kJ/mol
$H_2O(l) \rightarrow H_2(g) + ½O_2(g)$	$\Delta G° = 237.2$ kJ/mol
$P_4O_{10}(s) + 6\ H_2O(l) \rightarrow 4H_3PO_4(l)$	$\Delta G° = 630.2$ kJ/mol
$P(s) + 3/2\ H_2(g) + 2O_2(g) \rightarrow H_3PO_4(l)$	$\Delta G°_f = ?$

a. -1063
b. -265.7
c. 1063
d. 265.7
e. -123.0

3. Which of the following reactions has the largest positive molar entropy change?

a. $H_2O(s) \rightarrow H_2O(g)$
b. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$
c. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
d. $PCl_5(g) \rightarrow PCl_3(g) + Cl_2(g)$
e. $KClO_4(s) + 4C(s) \rightarrow KCl(s) + 4CO(g)$

4. Which quantity has a value of zero for an element in its standard state?

a. ΔH^o_f
b. S^o
c. ΔG^o_f
d. both a and c
e. all of a, b, and c

5. When ammonium nitrate dissolves in water, the solution becomes cold. We can conclude the following:

a. ΔH^o is positive and ΔS^o is positive
b. ΔH^o is positive and ΔS^o is negative
c. ΔH^o is negative and ΔS^o is negative
d. ΔH^o is negative and ΔS^o is positive
e. ΔH^o is positive and ΔS^o is zero

Answers

1. c
2. b
3. e
4. d
5. a

6. Thermodynamics is applied to learn about a reaction's — 6. e
   a. pathway
   b. mechanism
   c. stoichiometry
   d. rate
   e. spontaneity

7. In aqueous solution, iodine reacts with acetone as represented by the following equation: — 7. e

$$I_2 + CH_3COCH_3 \rightarrow CH_3COCH_2I + H^+ + I^-$$

The experimental rate law is

$$\text{Rate} = k[H^+][CH_3COCH_3]$$

According to the information above, an increase in the iodine concentration has what effect on the reaction?
   a. It increases ithe value of the equilibrium constant.
   b. It decreases the value of the equilibrium constant.
   c. It increases the rate of the reaction.
   d. It decreases the rate of the reaction.
   e. It does not affect the rate of the reaction.

8. At a constant temperature, which of the following would **not** affect the rate of a given chemical reaction? — 8. a
   a. the magnitude of ΔH
   b. the size of solid reactant particles
   c. the reaction temperature
   d. the concentration of one or more reactants
   e. a catalyst

9. Identify an intermediate in the following mechanism. — 9. a

$$O_3(g) = O_2(g) + O(g) \quad \text{(fast)}$$
$$O(g) + O_3(g) \rightarrow 2O_2(g) \quad \text{(slow)}$$

   a. $O(g)$
   b. $O_3(g)$
   c. $O_2(g)$
   d. $O_2(g)$ and $O(g)$
   e. $O_3(g)$ and $O_2(g)$

10. A first-order reaction has a rate constant of 0.021 s^{-1}. The half-life for this reaction is — 10. c
   a. 48 s
   b. 0.030 s
   c. 33 s
   d. 0.021 s
   e. Not enough data is provided for this calculation.

11. Hypochlorite ion oxidizes iodide ion in aqueous solution as represented by the equation: 11. b

$$OCl^- + I^- \rightarrow OI^- + Cl^-$$

The rate of formation of hypoiodite ion (OI^-) is given by the rate law

$$Rate = k[I^-][OCl^-]/[OH^-]$$

The overall reaction order is

a. 0
b. 1
c. 2
d. 3
e. $k[I^-][OCl^-]/[OH^-]$

12. The following data were measured for the reaction: 12. e

$$SO_2(g) + 2Cl_2(g) \rightarrow SOCl_2(g) + Cl_2O(g)$$

Experiment	$[SO_2](M)$	$[Cl_2](M)$	Initial Rate(M/s)
1	0.100	0.100	0.25
2	0.200	0.100	0.50
3	0.200	0.200	2.00
4	0.300	0.400	?

What is the missing value of the initial rate for experiment 4?

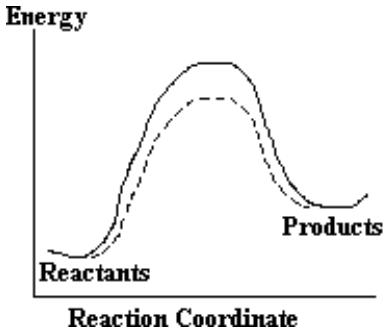
a. 0.75
b. 1.00
c. 3.00
d. 9.00
e. 12.0

13. In a chemical reaction at constant temperature, the addition of a catalyst 13. c

a. affects the equilibrium constant.
b. increases the fraction of molecules with high kinetic energy.
c. provides an alternate reaction pathway with a different activation energy.
d. decreases the energy released in the chemical reaction.
e. increases the concentration of the products at equilibrium.

14. Consider the following energy diagram for a chemical reaction. The lower dashed curve could represent

14. b



a. the reverse reaction.
b. the same reaction in the presence of a catalyst.
c. the same reaction at lower temperature.
d. the same reaction at higher temperature.
e. an intermediate in the reaction.

15. If the rate of a reaction increases by a factor of 64 when the concentration of reactant increases by a factor of 4, the order of the reaction with respect to this reactant is

15. d

a. 16
b. 2
c. 4
d. 3
e. 1

16. To determine whether the data available corresponds to a second-order rate law, a plot of which variables will yield a straight line?

16. e

a. ln [A] vs t
b. ln [A] vs 1/t
c. [A] vs t
d. $[A]^2$ vs t
e. 1/[A] vs t

17. The position of equilibrium would **not** be appreciably affected by changes in the volume of the container for

17. a

a. $N_2(g) + O_2(g) = 2NO(g)$
b. $N_2(g) + 3H_2(g) = 2NH_3(g)$
c. $H_2O_2(l) = H_2O(l) + \frac{1}{2}O_2(g)$
d. $P_4(s) + 6Cl_2(g) = 4PCl_3(l)$
e. $H_2(g) + I_2(s) = 2HI(g)$

18. Consider the following reaction: 18. b

$N_2O_4(g) = 2NO_2(g) \quad \Delta H = +58.2$ kJ

What will cause an increase in the concentration of NO_2 at equilibrium?

a. The NO_2 concentration will remain constant becaue it is equilibrium.
b. an increase in temperature
c. an increase in pressure
d. a decrease in volume
e. adding a catalyst

19. The equilibrium constant $K_c = 0.00450$ at 700 K for the reaction 19. d

$2HBr(g) = H_2(g) + Br_2(g)$

What is the concentration of HBr at equilibrium if the initial concentrations are $[HBr]_o = 0.460$ M, and $[H_2]_o = [Br_2]_o = 0$ M?

a. 0.00450
b. 0.0671
c. 0.259
d. 0.406
e. 0.208

20. Which **one** of the following statements is true regarding chemical equilibrium? 20. c

a. Chemical equilibrium can only be attained at high temperatures.
b. Chemical equilibrium can only be attained starting from the reactant side of the equilibrium.
c. At equilibrium, the reactant and product concentrations show no further change with time.
d. At equilibrium, the rate of the forward reaction is always greater than the rate of the reverse reaction.
e. At equilibrium, the product concentrations increase slightly with time.

21. If the ratio of the reaction quotient to the equilibrium constant, Q/K, is less than 1, 21. a

a. more products are formed.
b. the direction of reaction cannot be predicted.
c. the system is at equilibrium.
d. more reactants are formed.
e. no net change occurs.

22. At a certain temperature, a vessel contains 0.980 M $NH_3(g)$, 1.53 M $H_2(g)$, and 0.510 M $N_2(g)$ in a state of equilibrium. Calculate a value of K_c for the following reaction: 22. d

$N_2(g) + 3H_2(g) = 2NH_3(g)$

a. 1.26
b. 0.837
c. 3.02
d. 0.526
e. 1.96

23. Consider the following reaction

$$CaO(s) + CO_2(g) = CaCO_3(s)$$

The equilibrium constant expression is

a. $K = [CaCO_3]/[CaO]$
b. $K = [CaO][CO_2]/[CaCO_3]$
c. $K = 1/[CO_2]$
d. $K = [CO_2]$
e. $K = [CaCO_3]/[CaO][CO_2]$

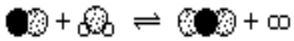
23. c

24. For the reaction, $MgCl_2(s) + ½O_2(g) = MgO(s) + Cl_2(g)$, $K = 2.98$. For the reaction, $2Cl_2(g) + 2MgO(s) = 2MgCl_2(s) + O_2(g)$, K is

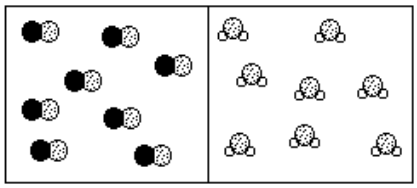
a. 1.73
b. 0.113
c. -8.88
d. 0.579
e. 0.336

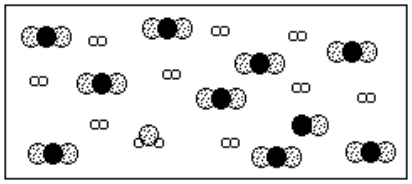
24. b

25. The following figure represents a set of initial conditions for the following reaction,



with K = 9. Select the molecular picture that shows what the system looks like when the barrier separating the reactants is removed and the system reaches equilibrium.



a.


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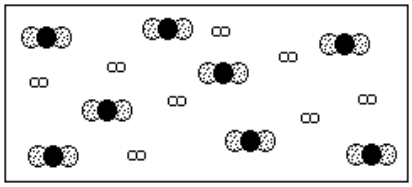
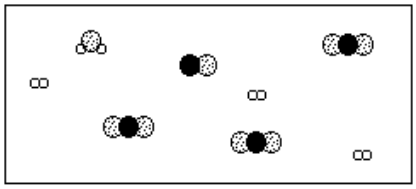
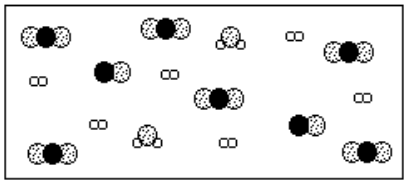
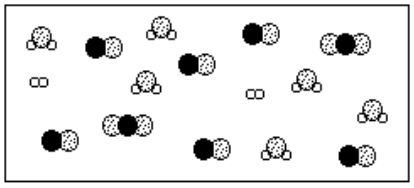


c.


d.


e.


25. d