PX0112-Solns, Kinetics & Equilibrium

____ 1. A student must prepare 5.00 L of 0.100 *M* Na_2CO_3 (106 g/mol). Which is the best procedure for preparing this solution?
A) Measure 53.0 g Na_2CO_3 and add 5.00 kg of H_2O.
B) Measure 10.6 g Na_2CO_3 and add 5.00 kg of H_2O.
C) Measure 53.0 g Na_2CO_3 and add H_2O until the final homogeneous solution has a volume of 5.00 L.
D) Measure 10.6 g Na_2CO_3 and add H_2O until the final homogeneous solution has a volume of 5.00 L.
E) Measure 53.0 g Na_2CO_3 and add 5.00 L of H_2O.

____ 2. What is the molarity of an NaI solution that contains 7.3 g of NaI in 28.0 mL of solution?
A) 1.7 *M*
B) 0.049 *M*
C) 0.0038 *M*
D) 0.00019 *M*
E) 0.26 *M*

____ 3. A 29.0-g sample of NaOH is dissolved in water, and the solution is diluted to give a final volume of 1.60 L. The molarity of the final solution is
A) 18.1 *M*.
B) 0.453 *M*.
C) 0.725 *M*.
D) 0.0552 *M*.
E) 0.862 *M*.

____ 4. What mass of oxalic acid dihydrate, $H_2C_2O_4 \cdot 2H_2O$, is required to prepare 250.0 mL of a 1.32 *M* solution of oxalic acid?
A) 126 g
B) 41.6 g
C) 119 g
D) 166 g
E) 29.7 g

____ 5. How many moles of sulfate ions are there in a 0.545-L solution of 0.489 *M* $Al_2(SO_4)_3$?
A) 0.267 mol
B) 0.800 mol
C) 3.34 mol
D) 0.0888 mol
E) 2.69 mol

____ 6. Which of the following solutions contains the largest number of moles of dissolved particles?
A) 25. mL of 5.0 *M* sodium chloride
B) 25. mL of 2.0 *M* sulfuric acid
C) 200. mL of 0.10 *M* sodium hydroxide
D) 50. mL of 1.0 *M* hydrochloric acid
E) 100. mL of 0.5 *M* nitric acid

____ 7. How many moles of KOH are present in 25.4 mL of 0.965 *M* KOH?

A) 2.63×10^{-2} mol
B) 26.3 mol
C) 2.45×10^{-2} mol
D) 24.5 mol
E) 0.965 mol

____ 8. Calculate the molarity of a solution that contains 32.5 g of NaOH (40.0 g/mol) in 469 mL of solution.

A) 0.381 *M*
B) 2.77×10^{3} *M*
C) 0.577 *M*
D) 3.81×10^{5} *M*
E) 1.73 *M*

____ 9. To dilute 1.00 L of a 0.600 *M* to 0.100 *M*, the final volume must be

A) 60 L.
B) 0.7 L.
C) 1/6 the original volume.
D) More information is needed to answer this question.
E) 6 times the original volume.

____ 10. In order to dilute 35.5 mL of 0.533 *M* HCl to 0.100 *M*, the volume of water that must be added is

A) 28.8 mL.
B) 6.66 mL.
C) 1.89×10^{2} mL.
D) 1.50×10^{-3} mL.
E) 1.54×10^{2} mL.

____ 11. A dilute solution is prepared by transferring 45.00 mL of a 0.5616 M stock solution to a 400.0 mL volumetric flask and diluting to mark. What is the molarity of this dilute solution?

A) 0.06318 *M*
B) 0.1264 *M*
C) 0.04992 *M*
D) 0.01580 *M*
E) 0.2808 *M*

____ 12. The concentration of sulfate in a sample of wastewater is to be determined by using gravimetric analysis. To a 100.0-mL sample of the wastewater is added an excess of calcium nitrate, forming the insoluble calcium sulfate (136.1 g/mol) according to the balanced equation given below. The solid calcium sulfate is dried, and its mass is measured to be 0.7272 g. What was the concentration of sulfate in the original wastewater sample?

$SO_4^{2-}(aq) + Ca(NO_3)_2(aq) \rightarrow CaSO_4(s) + 2NO_3^{-}(aq)$

A) 0.05343 *M*
B) 0.9897 *M*

C) 18.72 *M*
D) 1.872 *M*
E) 9.897 *M*

____ 13. What minimum mass of copper (II) nitrate must be added to 30.0 mL of a 0.0387 *M* phosphate solution in order to completely precipitate all of the phosphate as solid copper (II) phosphate?

$2PO_4^{3-}(aq) + 3Cu(NO_3)_2(aq) \rightarrow Cu_3(PO_4)_2(s) + 6NO_3^-(aq)$

A) 0.218 g
B) 0.653 g
C) 0.145 g
D) 0.0726 g
E) 0.327 g

____ 14. The reaction of H_2SO_4 with NaOH is represented by the equation

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

What volume of 0.587 *M* H_2SO_4 is required to neutralize 12.7 mL of 0.302 *M* NaOH?
A) 3.27 mL
B) 1.70 mL
C) 6.53 mL
D) 12.7 mL
E) 24.7 mL

____ 15. In a volumetric analysis experiment, an acidic aqueous solution of methanol (CH_3OH) is titrated with a solution of potassium dichromate ($K_2Cr_2O_7$) according to the following balanced chemical equation:

$2K_2Cr_2O_7(aq) + 8H_2SO_4(aq) + 3CH_3OH(aq) \rightarrow 2Cr_2(SO_4)_3(aq) + 11H_2O(l) + 3HCOOH(aq) + 2K_2SO_4(aq)$

What volume of 0.00389 *M* $K_2Cr_2O_7$ is required to titrate 1.77 g of CH_3OH dissolved in 20.0 mL of solution?
A) 21.3 mL
B) 683 mL
C) 9.47 mL
D) 20.0 mL
E) 303 mL

____ 16. A 40.00-mL sample of a weak base is titrated with 0.0935 *M* HCl. At the endpoint, it is found that 32.87 mL of titrant was used. What was the concentration of the weak base?
A) 0.114 *M*
B) 7.11×10^{-5} *M*
C) 3.07 *M*
D) 0.0935 *M*
E) 0.0768 *M*

____ 17. In a volumetric analysis experiment, an acidic aqueous solution of methanol (CH_3OH) is titrated with a solution of potassium dichromate ($K_2Cr_2O_7$) according to the following balanced chemical equation:

$2K_2Cr_2O_7(aq) + 8H_2SO_4(aq) + 3CH_3OH(aq) \rightarrow 2Cr_2(SO_4)_3(aq) + 11H_2O(l) + 3HCOOH(aq) + 2K_2SO_4(aq)$

It required 43.91 mL of 0.0435 *M* $K_2Cr_2O_7$ to reach the endpoint. What mass of CH_3OH was present initially?

A) 0.0918 g
B) 2.09 g
C) 0.929 g
D) 0.0612 g
E) 0.0408 g

____ 18. The oxidation of ammonia produces nitrogen and water via the following reaction:

$4NH_3(g) + 3O_2(g) \rightarrow 2N_2(g) + 6H_2O(l)$

Suppose the rate of formation of $H_2O(l)$ is 3.0 mol/(L • s). Which of the following statements is true?

A) The rate of consumption of NH_3 is 2.0 mol/(L • s).
B) The rate of consumption of O_2 is 2.0 mol/(L • s).
C) The rate of formation of N_2 is 1.3 mol/(L • s).
D) The rate of formation of N_2 is 2.0 mol/(L • s).
E) The rate of consumption of NH_3 is 0.50 mol/(L • s).

____ 19. For the hypothetical reaction A + 2B → 2C + D, the initial rate of disappearance of A is 2.0×10^{-2} mol/(L • s). What is the initial rate of disappearance of B?

A) 8.0×10^{-2} mol/(L • s)
B) 4.0×10^{-2} mol/(L • s)
C) 1.4×10^{-1} mol/(L • s)
D) 4.0×10^{-4} mol/(L • s)
E) 1.4×10^{-2} mol/(L • s)

____ 20. In the reaction $2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$, the initial concentration of H_2O_2 is 0.542 *M* and, 21.2 seconds later, the concentration of H_2O_2 is 0.310 *M*. What is the average rate of reaction over this time interval?

A) –0.0109 *M*/s
B) 0.0109 *M*/s
C) 0.0146 *M*/s
D) 0.00547 *M*/s
E) –0.00547 *M*/s

____ 21. Which of the following statements is true concerning the reaction given below?

$2H_2S(g) + O_2(g) \rightarrow 2S(s) + 2H_2O(g)$

A) The rate law is Rate = $k[H_2S]^2[O_2]$.
B) The reaction is second-order in $H_2S(g)$ and first-order in $O_2(g)$.

C) The reaction is first-order in $H_2S(g)$ and second-order in $O_2(g)$.
D) The rate law is Rate = $k[H_2S][O_2]$.
E) The rate law may be determined only by experiment.

____ 22. For which of the following hypothetical rate laws would the units of the rate constant have the general form $M^{-2}\cdot$time^{-1}?
A) rate = $k[A]^3$
B) rate = $k[A]^4$
C) rate = $k[A]^2$
D) rate = $k[A]$
E) rate = k

____ 23. For a certain first-order reaction with the general form aA → products, the rate is 0.32 $M\cdot s^{-1}$ when the concentration of the reactant is 0.29 M. What is the rate constant for this reaction?
A) 0.26 s^{-1}
B) 1.1 s^{-1}
C) 0.32 s^{-1}
D) 3.1 s^{-1}
E) 3.8 s^{-1}

____ 24. The balanced chemical equation and rate law for the reaction between $NO(g)$ and $H_2(g)$ at a particular temperature are

$2NO(g) + 2H_2(g) \rightarrow N_2(g) + 2H_2O(g)$

Rate = $k[NO]^2[H_2]$

What is the reaction order with respect to hydrogen?
A) 4
B) 0
C) 2
D) 3
E) 1

____ 25. The rate law for the chemical reaction

$5Br^-(aq) + BrO_3^-(aq) + 6H^+(aq) \rightarrow 3Br_2(aq) + 3H_2O(l)$

has been determined experimentally to be Rate = $k[Br^-][BrO_3^-][H^+]^2$. What is the overall order of the reaction?
A) 3
B) 5
C) 4
D) 2
E) 1

____ 26. The following data were obtained for the hypothetical reaction 2A + B → products.

$[A]_0$ (M)	$[B]_0$ (M)	Initial Rate (M/s)
0.2	0.1	5
0.2	0.2	20

0.6	0.1	45

What is the overall order of this reaction?
A) 3
B) 1/2
C) 0
D) 4
E) 1

____ 27. For the reaction

$(CH_3)_3CCl(aq) + OH^-(aq) \rightarrow (CH_3)_3COH(aq) + Cl^-(aq)$

it is found experimentally that doubling the initial concentration of $(CH_3)_3CCl$ causes the initial reaction rate to double, but doubling the initial concentration of OH^- has no effect on the rate. What is the rate law?
A) Rate = $k[(CH_3)_3CCl]^2[OH^-]$
B) Rate = $k[(CH_3)_3CCl][OH^-]$
C) Rate = $k\frac{[(CH_3)_3COH][Cl]}{[(CH_3)_3CCl][OH]}$
D) Rate = $k[(CH_3)_3COH][Cl^-]$
E) Rate = $k[(CH_3)_3CCl]$

____ 28. Nitrosyl chloride is produced from the reaction of nitrogen monoxide and chlorine:

$2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$

The following initial rates at a given temperature were obtained for the concentrations listed below.

Experiment	Initial Rate ($mol\cdot L^{-1}\cdot h^{-1}$)	$[NO]_0$ ($mol\cdot L^{-1}$)	$[Cl_2]_0$ ($mol\cdot L^{-1}$)
1	2.21	0.25	0.25
2	19.89	0.75	0.25
3	6.63	0.25	0.75

From the data, what is the experimental rate law?
A) Rate = $k[Cl_2]$
B) Rate = $k[NO]$
C) Rate = $k[NO][Cl_2]^2$
D) Rate = $k[NO]^2[Cl_2]$
E) Rate = $k[NO][Cl_2]^{1/2}$

____ 29. At a given temperature, a first-order reaction has a rate constant of 3.5×10^{-3} s^{-1}. How long will it take for the reaction to be 24% complete?
A) 410 s
B) 1200 s
C) 910 s
D) 34 s
E) 78 s

____ 30. The nuclide ^{96}Nb decays by a first-order process with a rate constant of 2.96×10^{-2} h^{-1}. How long will it take for 82.0% of the initial amount of ^{96}Nb to be consumed?

A) 33.8 h
B) 57.9 h
C) 27.7 h
D) 6.70 h
E) 6.08 h

____ 31. For the hypothetical first-order reaction A → products, $k = 0.0839$ s^{-1}. If the initial concentration of A is 0.640 *M*, how long would it take for A to be 66.4% consumed?

A) 8.26 s
B) 13.0 s
C) 11.9 s
D) 18.6 s
E) 4.88 s

____ 32. At 500°C, cyclopropane (C_3H_6) reacts to form its isomer, propene (C_3H_6). The reaction is first-order, and the rate constant is 6.7×10^{-4} s^{-1}. If the initial concentration of cyclopropane is 0.500 *M* and the initial concentration of propene is 0, determine the time required for the concentration of <u>propene</u> to reach 0.100 *M*.

A) 3.4×10^3 s
B) 3.3×10^2 s
C) 1.2×10^4 s
D) 7.5×10^2 s
E) 2.4×10^3 s

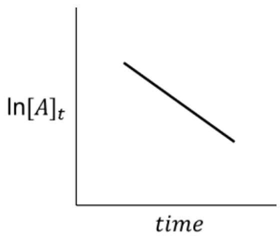
____ 33. The reaction A → products is first-order in A. If the concentration of A is cut in half, the half-life of the reaction will

A) decrease by a factor of 1/2.
B) double.
C) decrease by a factor of 1/4.
D) remain constant.
E) quadruple.

____ 34. A first-order chemical reaction is observed to have a rate constant of 25 min^{-1}. What is the corresponding half-life for the reaction?

A) 1.7 s
B) 1.7 min
C) 36 min
D) 2.4 s
E) 35.8 s

____ 35. For the hypothetical reaction *a*A → products, the experimental data showed the following behavior (below). What is the reaction order with respect to reactant A?



A) first-order
B) second-order
C) zero-order
D) third-order
E) fourth-order

____ 36. Which of the following statements best describes the condition(s) needed for a successful formation for a product according to the collision model?
A) The relative orientation of the particles has an effect only if the kinetic energy of the particles is below some minimum value.
B) The collision must involve a sufficient amount of energy, provided from the motion of the particles, to overcome the activation energy.
C) The relative orientation of the particles must allow for formation of the new bonds in the product.
D) The energy of the incoming particles must be above a certain minimum value, and the relative orientation of the particles must allow for formation of new bonds in the product.
E) The relative orientation of the particles has little or no effect on the formation of the product.

____ 37. Which of the following changes will affect the rate constant of a reaction?

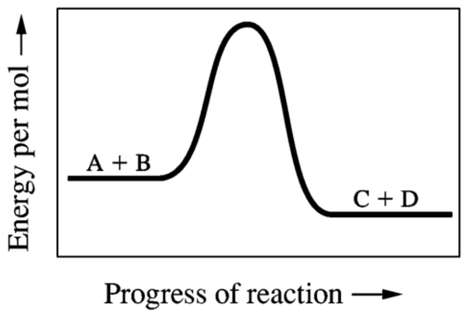
1. Increasing or decreasing the reaction temperature.
2. Adding a catalyst.
3. Increasing or decreasing the reactant concentrations.

A) 1 only
B) 2 only
C) 3 only
D) 1 and 2
E) 1, 2, and 3

____ 38. What would happen if the kinetic energy of the reactants were not enough to provide the needed activation energy?
A) The rate of the reaction would tend to increase.
B) The reactants would continue to exist in their present form.
C) The activated complex would be converted into products.
D) The products would be produced at a lower energy state.
E) The products would form at an unstable energy state.

____ 39. The potential-energy diagram below describes the hypothetical reaction A + B → C + D. Assuming the *y*-axis label refers to the enthalpy(*H*) per mol, which of the following statements concerning this reaction coordinate is/are correct?

1. The forward reaction is exothermic.
2. The forward reaction rate is proportional to the change in enthalpy (ΔH) of the forward reaction.
3. E_a(forward) – E_a(reverse) is equal to the change in enthalpy (ΔH) of the forward reaction.



A) 1 only
B) 2 only
C) 3 only
D) 1 and 3
E) 1, 2, and 3

____ 40. For the formation of 1 mol of nitrosyl chloride at a given temperature, ΔH = –44 kJ.

$NO(g) + 1/2\ Cl_2(g) \rightarrow NOCl(g)$

The activation energy for this reaction is 59 kJ/mol. What is the activation energy for the reverse reaction?

A) 59 kJ/mol
B) 15 kJ/mol
C) 103 kJ/mol
D) –44 kJ/mol
E) –103 kJ/mol

____ 41. The rate constant for a first-order reaction is $1.6 \times 10^{-2}\ s^{-1}$ at 668 K and $5.1 \times 10^{-2}\ s^{-1}$ at 916 K. What is the activation energy? (R = 8.31 J/(mol · K))

A) 11 kJ/mol
B) 14 kJ/mol
C) 23 kJ/mol
D) 2900 kJ/mol
E) 24 kJ/mol

____ 42. Which of the following statements is true in a reaction system at equilibrium?

A) The equilibrium constant is zero.
B) The number of collisions per unit time between reactants is equal to the number of

collisions per unit time between products.
C) Reactants are reacting to form products at the same rate as products are reacting to form reactants.
D) Reactants and products are present in equimolar amounts.
E) The product of the concentrations of the products divided by the product of the concentrations of the reactants is always a constant.

____ 43. Which of the following is/are true concerning a chemical reaction *at equilibrium*?

1. The system will be a mixture of reactant and products.
2. The rate of the forward and reverse reactions are equal.
3. The amount of each reactant and product is constant.

A) 1 only
B) 2 only
C) 3 only
D) 1 and 2
E) 1, 2, and 3

____ 44. A 15.00-L vessel at 700 K initially contains HI(*g*) at a pressure of 4.00 atm; at equilibrium, it is found that the partial pressure of $H_2(g)$ is 0.387 atm. What is the partial pressure of HI(*g*) at equilibrium?

$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$

A) 4.00 atm
B) 3.61 atm
C) 3.23 atm
D) 4.39 atm
E) 0.387 atm

____ 45. The following reaction is investigated (assume an ideal gas mixture):

$2N_2O(g) + N_2H_4(g) \rightleftharpoons 3N_2(g) + 2H_2O(g)$

Initially there are 0.100 mol of N_2O and 0.25 mol of N_2H_4, in a 10.0-L container. If there are 0.062 mol of N_2O at equilibrium, how many moles of N_2 are present at equilibrium?
A) 3.8×10^{-2}
B) 1.1×10^{-1}
C) 5.7×10^{-2}
D) 1.9×10^{-2}
E) none of these

____ 46. What is the expression for K_c for the following equilibrium?

$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

A) $[CaO][CO_2]$
B) $[CO_2]$

C) $\dfrac{[CaO][CO_2]}{[CaCO_3]}$

D) $\dfrac{[CaCO_3]}{[CaO][CO_2]}$

E) $\dfrac{1}{[CO_2]}$

____ 47. Which of the following correctly describes the equilibrium constant for the gas-phase reaction between H_2 and O_2 to form gaseous H_2O?

A) $K_c = \dfrac{[H_2][O_2]}{[H_2O]}$

B) $K_c = \dfrac{[H_2O]}{[H_2][O_2]}$

C) $K_c = [H_2O]$

D) $K_c = \dfrac{[H_2O]^2}{[H_2]^2[O_2]}$

E) $K_c = \dfrac{[H_2O]^2}{[H_2][O_2]}$

____ 48. For the reaction $Br_2(g) + Cl_2(g) \rightleftharpoons 2BrCl(g)$, at equilibrium, it is found that the concentrations of Br_2, Cl_2, and BrCl are 0.398 *M*, 0.351 *M*, and 2.05×10^{-3} *M*, respectively. What is the value of K_c?

A) 3.01×10^{-5}
B) 1.20×10^{-4}
C) 1.47×10^{-2}
D) 6.81×10^{1}
E) 3.32×10^{4}

____ 49. At 400 K, an equilibrium mixture of H_2, I_2, and HI consists of 0.065 mol H_2, 0.079 mol I_2, and 0.13 mol HI in a 4.50-L flask. What is the value of K_p for the following equilibrium? (R = 0.0821 L • atm/(K • mol))

$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$

A) 0.29
B) 8.2
C) 0.039
D) 26
E) 3.4

____ 50. A sample of ammonia gas was allowed to come to equilibrium at 400 K.

$2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$

At equilibrium, it was found that the concentration of H_2 was 0.0367 *M*, the concentration of N_2 was 0.0122 *M*, and the concentration of NH_3 was 0.170 *M*. What was the initial concentration of ammonia?

A) 0.122 *M*
B) 0.146 *M*
C) 0.218 *M*
D) 0.182 *M*
E) 0.194 *M*

____ 51. If K_c = 0.145 for $A_2 + 2B \rightleftharpoons 2AB$, what is the value of K_c for the reaction

$4AB \rightleftharpoons 2A_2 + 4B$?

A) 0.145
B) 0.290
C) 47.6
D) –0.145
E) 3.45

____ 52. Given the equilibrium constants for the equilibria,

$2NH_4^+(aq) + 2H_2O(l) \rightleftharpoons 2NH_3(aq) + 2H_3O^+(aq)$; $K_c = 3.24 \times 10^{-19}$

$CH_3COOH(aq) + H_2O(l) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$; $K_c = 1.75 \times 10^{-5}$

determine K_c for the following equilibrium.

$CH_3COOH(aq) + NH_3(aq) \rightleftharpoons CH_3COO^-(aq) + NH_4^+(aq)$

A) 3.08×10^4
B) 3.25×10^{-5}
C) 9.96×10^{-15}
D) 1.00×10^{14}
E) 1.75×10^{-5}

____ 53. What is the K_c equilibrium-constant expression for the following equilibrium?

$S_8(s) + 24F_2(g) \rightleftharpoons 8SF_6(g)$

A) $\frac{[SF_6]}{[S_8][F_2]}$

B) $\frac{[SF_6]^8}{[S_8][F_2]^{24}}$

C) $\frac{[F_2]^{24}}{[SF_6]^8}$

D) $\frac{[S_8][F_2]^{24}}{[SF_6]^8}$

E) $\frac{[SF_6]^8}{[F_2]^{24}}$

____ 54. For which of the following values of the equilibrium constant does the reaction mixture contain mostly reactants?
A) 10^0
B) 10^1
C) 10^{-9}
D) 10^{-1}
E) 10^9

____ 55. For which of the following reactions will the reactant experience the largest degree of decomposition upon reaching equilibrium at 500 K?
A) $2NO_2F(g) \rightleftharpoons 2NO_2(g) + F_2(g)$; $K_p = 6.6 \times 10^{-22}$
B) $2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$; $K_p = 1.3 \times 10^{-5}$
C) $2NOF(g) \rightleftharpoons 2NO(g) + F_2(g)$; $K_p = 1.2 \times 10^{-26}$
D) $2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$; $K_p = 1.7 \times 10^{-2}$
E) $2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g)$; $K_p = 5.9 \times 10^{-5}$

____ 56. Consider the following reaction:

$2HF(g) \rightleftharpoons H_2(g) + F_2(g)(K_c = 1.00 \times 10^{-2})$

Given that 1.00 mol of HF(*g*), 0.371 mol of $H_2(g)$, and 0.750 mol of $F_2(g)$ are mixed in a 5.00-L flask, determine the reaction quotient, *Q*.
A) *Q* = 0.0696
B) *Q* = 0.278
C) *Q* = 0.0557
D) *Q* = 2.12
E) none of these

____ 57. Consider the following equilibrium:

$C_2H_6(g) + C_5H_{12}(g) \rightleftharpoons CH_4(g) + C_6H_{14}(g)$; $K_p = 9.57$ at 500 K

Suppose 47.2 g each of CH_4, C_2H_6, C_5H_{12}, and C_6H_{14} are placed in a 25.0-L reaction vessel at 500 K. Which of the following statements is correct?
A) Because $Q_c < K_c$, more products will be formed.
B) Because $Q_c = 1$, the system is at equilibrium.
C) Because $Q_c = 1$, more products will be formed.
D) Because $Q_c = 1$, more reactants will be formed.
E) Because $Q_c > K_c$, more reactants will be formed.

____ 58. What is the reaction quotient (Q) for the equilibrium

$CuSCN(s) \rightleftharpoons Cu^+(aq) + SCN^-(aq)$

when 0.3317 L of 2.000×10^{-7} M Cu^+ is combined with 0.1018 L of 4.000×10^{-7} M SCN^- in the presence of an excess of CuSCN(*s*)?

A) 1.437×10^{-14}
B) 8.000×10^{-14}
C) 2.701×10^{-15}
D) 6.232×10^{-15}
E) 1.503×10^{-14}

____ 59. For the equilibrium $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$, $K_c = 2.0 \times 10^1$ at 240°C. If pure PCl_5 is placed in a 1.00-L container and allowed to come to equilibrium, and the equilibrium concentration of $PCl_3(g)$ is 0.47 M, what is the equilibrium concentration of $PCl_5(g)$?

A) 0.94 M
B) 0.24 M
C) 0.024 M
D) 0.011 M
E) 6.5 M

____ 60. Hydrogen iodide undergoes decomposition according to the equation

$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$

The equilibrium constant K_p at 500 K for this equilibrium is 0.060. Suppose 0.520 mol of HI is placed in a 1.00-L container at 500 K. What is the equilibrium concentration of $H_2(g)$?
(R = 0.0821 L • atm/(K • mol))

A) 0.14 M
B) 0.085 M
C) 4.2 M
D) 0.025 M
E) 0.10 M

____ 61. Which of the following, when added to an equilibrium mixture represented by the equlibrium below, will not alter the composition of the original equilibrium mixture?

$Mg(OH)_2(s) \rightleftharpoons Mg^{2+}(aq) + 2OH^-(aq)$

A) Addition of $Mg(NO_3)_2(s)$ to the equilibrium mixture.
B) Addition of $Fe(NO_3)_3(aq)$ from the equilibrium mixture.
C) Addition of $Mg(OH)_2(s)$ to the equilibrium mixture.
D) Addition of HCl(*aq*) to the equilibrium mixture.
E) Addition of NaOH(*s*) to the equilibrium mixture.

____ 62. Which of the following equilibria would not be affected by pressure changes at constant temperature?

A) $CO_2(g) + H_2(g) \rightleftharpoons CO(g) + H_2O(g)$
B) $CO(g) + \frac{1}{2}O_2(g) \rightleftharpoons CO_2(g)$
C) $2Hg(l) + O_2(g) \rightleftharpoons 2HgO(s)$

D) $2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(l)$
E) $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

____ 63. Which of the following equilibria would be affected by volume changes at constant temperature?

1. $2NO(g) + 3F_2(g) \rightleftharpoons 2F_3NO(g)$
2. $PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$
3. $O_3(g) + NO(g) \rightleftharpoons NO_2(g) + O_2(g)$

A) 1 only
B) 2 only
C) 3 only
D) 1 and 2
E) 1, 2, and 3

____ 64. Ammonia is prepared industrially by the reaction

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

For the reaction, DH° = –92.2 kJ and K (at 25°C) = 4.0 ´ 10^8. When the temperature of the reaction is increased to 500°C, which of the following statements is true?
A) At equilibrium, more NH_3 is present at 500°C than at 25°C.
B) The reaction of N_2 with H_2 to form ammonia is endothermic.
C) K for the reaction will be larger at 500°C than at 25°C.
D) Product formation (at equilibrium) is less favored as the temperature is raised.
E) None of the above statements is true.

____ 65. Consider the following equilibrium at 25°C:

$2ICl(g) \rightleftharpoons I_2(g) + Cl_2(g)$; D$H$ = 27 kJ; $K_p = 6.2 \times 10^{-6}$

Which of the following would be true if the temperature were increased to 100°C?

1. The value of K_p would increase.
2. The concentration of ICl(g) would increase.
3. The partial pressure of I_2 would increase.

A) 1 only
B) 2 only
C) 3 only
D) 1 and 2
E) 1 and 3

____ 66. Solid HgO, liquid Hg, and gaseous O_2 are placed in a glass bulb and allowed to reach equilibrium.

$2HgO(s) \rightleftharpoons 2Hg(l) + O_2(g)$; D$H$ = 181.6 kJ

The amount of Hg(l) in the bulb could be increased
A) by removing some HgO(s).
B) by adding an inert gas.
C) by adding some HgO(s).
D) by increasing the pressure.

E) by increasing the temperature.

____ 67. Consider the reaction

$S_2Cl_2(l) + CCl_4(l) \rightleftharpoons CS_2(g) + 3Cl_2(g)$; D$H°$ = 84.3 kJ

If the above reactants and products are contained in a closed vessel and the reaction system is at equilibrium, the number of moles of CS_2 can be increased by

A) increasing the size of the reaction vessel.
B) adding some Cl_2 to the system.
C) adding some S_2Cl_2 to the system.
D) decreasing the temperature of the reaction system.
E) adding some CCl_4 to the system.

____ 68. For the endothermic reaction $2CO_2(g) + N_2(g) \rightleftharpoons 2NO(g) + 2CO(g)$, the conditions that favor maximum conversion of the reactants to products are

A) high temperature and low pressure.
B) high temperature, pressure being unimportant.
C) low temperature and low pressure.
D) low temperature and high pressure.
E) high temperature and high pressure.

PX0112-Solns, Kinetics & Equilibrium
Answer Section

1. ANS: C PTS: 1 DIF: moderate REF: 4.7
OBJ: Define molarity or molar concentration of a solution.
TOP: chemical reactions | working with solutions KEY: concentration
MSC: general chemistry
2. ANS: A PTS: 1 DIF: easy REF: 4.7
OBJ: Calculate the molarity from mass and volume. (Example 4.9)
TOP: chemical reactions | working with solutions KEY: concentration
MSC: general chemistry
3. ANS: B PTS: 1 DIF: easy REF: 4.7
OBJ: Calculate the molarity from mass and volume. (Example 4.9)
TOP: chemical reactions | working with solutions KEY: concentration
MSC: general chemistry
4. ANS: B PTS: 1 DIF: moderate REF: 4.7
OBJ: Use molarity as a conversion factor. (Example 4.10)
TOP: chemical reactions | working with solutions KEY: concentration
MSC: general chemistry
5. ANS: B PTS: 1 DIF: moderate REF: 4.7
OBJ: Use molarity as a conversion factor. (Example 4.10)
TOP: chemical reactions | working with solutions KEY: concentration
MSC: general chemistry
6. ANS: A PTS: 1 DIF: moderate REF: 4.7
OBJ: Use molarity as a conversion factor. (Example 4.10)
TOP: chemical reactions | working with solutions KEY: concentration
MSC: general chemistry
7. ANS: C PTS: 1 DIF: moderate REF: 4.7
OBJ: Use molarity as a conversion factor. (Example 4.10)
TOP: chemical reactions | working with solutions KEY: concentration
MSC: general chemistry
8. ANS: E PTS: 1 DIF: moderate REF: 4.7
OBJ: Use molarity as a conversion factor. (Example 4.10)
TOP: chemical reactions | working with solutions KEY: concentration
MSC: general chemistry
9. ANS: E PTS: 1 DIF: easy REF: 4.8
OBJ: Describe what happens to the concentration of a solution when it is diluted.
TOP: chemical reactions | working with solutions KEY: diluting solutions
MSC: general chemistry
10. ANS: E PTS: 1 DIF: moderate REF: 4.8
OBJ: Perform calculations associated with dilution.
TOP: chemical reactions | working with solutions KEY: diluting solutions
MSC: general chemistry
11. ANS: A PTS: 1 DIF: easy REF: 4.8
OBJ: Diluting a solution. (Example 4.11)

TOP: chemical equilibrium | working with solutions

12. ANS: A PTS: 1 DIF: moderate REF: 4.9
OBJ: Determine the amount of a species by gravimetric analysis. (Example 4.12)
TOP: chemical reactions | quantitative analysis KEY: gravimetric analysis
MSC: general chemistry

13. ANS: E PTS: 1 DIF: difficult REF: 4.9
OBJ: Determine the amount of a species by gravimetric analysis. (Example 4.12)
TOP: chemical reactions | quantitative analysis KEY: gravimetric analysis
MSC: general chemistry

14. ANS: A PTS: 1 DIF: moderate REF: 4.10
OBJ: Calculate the volume of reactant solution needed to perform a reaction. (Example 4.13)
TOP: chemical reactions | quantitative analysis

15. ANS: C PTS: 1 DIF: moderate REF: 4.10
OBJ: Calculate the volume of reactant solution needed to perform a reaction. (Example 4.13)
TOP: chemical reactions | quantitative analysis KEY: volumetric analysis
MSC: general chemistry

16. ANS: E PTS: 1 DIF: moderate REF: 4.10
OBJ: Calculate the quantity of substance in a titrated solution. (Example 4.14)
TOP: chemical reactions | quantitative analysis KEY: volumetric analysis
MSC: general chemistry

17. ANS: A PTS: 1 DIF: moderate REF: 4.10
OBJ: Calculate the quantity of substance in a titrated solution. (Example 4.14)
TOP: chemical reactions | quantitative analysis KEY: volumetric analysis
MSC: general chemistry

18. ANS: A PTS: 1 DIF: easy REF: 13.1
OBJ: Explain how the different ways of expressing reaction rates are related. (Example 13.1)
TOP: rates of reaction | reaction rate KEY: dependence of rate on concentration
MSC: general chemistry

19. ANS: B PTS: 1 DIF: easy REF: 13.1
OBJ: Explain how the different ways of expressing reaction rates are related. (Example 13.1)
TOP: rates of reaction | reaction rate KEY: change of concentration with time
MSC: general chemistry

20. ANS: D PTS: 1 DIF: easy REF: 13.1
OBJ: Calculate average reaction rate. (Example 13.2)
TOP: rates of reaction | reaction rate KEY: change of concentration with time
MSC: general chemistry

21. ANS: E PTS: 1 DIF: easy REF: 13.3
OBJ: Define and provide examples of a rate law, rate constant, and reaction order.
TOP: rates of reaction | reaction rate
KEY: dependence of rate on concentration | determining the rate law
MSC: general chemistry

22. ANS: A PTS: 1 DIF: easy REF: 13.3
OBJ: Define and provide examples of a rate law, rate constant, and reaction order.
TOP: rates of reaction | reaction rate

23. ANS: B PTS: 1 DIF: easy REF: 13.3

OBJ: Define and provide examples of a rate law, rate constant, and reaction order.
TOP: rates of reaction | reaction rate

24. ANS: E PTS: 1 DIF: easy REF: 13.3
OBJ: Determine the order of reaction from the rate law. (Example 13.3)
TOP: rates of reaction | reaction rate

25. ANS: C PTS: 1 DIF: easy REF: 13.3
OBJ: Determine the order of reaction from the rate law. (Example 13.3)
TOP: rates of reaction | reaction rate
KEY: dependence of rate on concentration | reaction order MSC: general chemistry

26. ANS: D PTS: 1 DIF: easy REF: 13.3
OBJ: Determine the rate law from initial rates. (Example 13.4)
TOP: rates of reaction | reaction rate
KEY: dependence of rate on concentration | determining the rate law
MSC: general chemistry

27. ANS: E PTS: 1 DIF: easy REF: 13.3
OBJ: Determine the rate law from initial rates. (Example 13.4)
TOP: rates of reaction | reaction rate
KEY: dependence of rate on concentration | determining the rate law
MSC: general chemistry

28. ANS: D PTS: 1 DIF: easy REF: 13.3
OBJ: Determine the rate law from initial rates. (Example 13.4)
TOP: rates of reaction | reaction rate
KEY: dependence of rate on concentration | determining the rate law
MSC: general chemistry

29. ANS: E PTS: 1 DIF: moderate REF: 13.4
OBJ: Use an integrated rate law. (Example 13.5)
TOP: rates of reaction | reaction rate KEY: integrated rate laws | first-order reaction
MSC: general chemistry

30. ANS: B PTS: 1 DIF: moderate REF: 13.4
OBJ: Use an integrated rate law. (Example 13.5)
TOP: rates of reaction | reaction rate KEY: integrated rate laws | first-order reaction
MSC: general chemistry

31. ANS: B PTS: 1 DIF: moderate REF: 13.4
OBJ: Use an integrated rate law. (Example 13.5)
TOP: rates of reaction | reaction rate KEY: integrated rate laws | first-order reaction
MSC: general chemistry

32. ANS: B PTS: 1 DIF: difficult REF: 13.4
OBJ: Use an integrated rate law. (Example 13.5)
TOP: rates of reaction | reaction rate KEY: integrated rate laws | first-order reaction
MSC: general chemistry

33. ANS: D PTS: 1 DIF: easy REF: 13.4
OBJ: Define half-life of a reaction. TOP: rates of reaction | reaction rate
KEY: integrated rate laws | half-life of a reaction MSC: general chemistry

34. ANS: A PTS: 1 DIF: easy REF: 13.4
OBJ: Relate the half-life of a reaction to the rate constant. (Example 13.6)
TOP: rates of reaction | reaction rate KEY: integrated rate laws | half-life

MSC: general chemistry

35. ANS: A PTS: 1 DIF: moderate REF: 13.4
OBJ: Plot kinetic data to determine the order of a reaction.
TOP: rates of reaction | reaction rate

36. ANS: D PTS: 1 DIF: easy REF: 13.5
OBJ: State the postulates of collision theory.
TOP: rates of reaction | reaction rate KEY: collision theory
MSC: general chemistry

37. ANS: D PTS: 1 DIF: easy REF: 13.5
OBJ: State the postulates of collision theory.
TOP: rates of reaction | reaction rate

38. ANS: B PTS: 1 DIF: moderate REF: 13.5
OBJ: Explain activation energy (Ea). TOP: rates of reaction | reaction rate
KEY: collision theory | activation energy MSC: general chemistry

39. ANS: D PTS: 1 DIF: moderate REF: 13.5
OBJ: Describe and interpret potential-energy curves for endothermic and exothermic reactions.
TOP: rates of reaction | reaction rate

40. ANS: C PTS: 1 DIF: easy REF: 13.5
OBJ: Describe and interpret potential-energy curves for endothermic and exothermic reactions.
TOP: rates of reaction | reaction rate KEY: collision theory | activation energy
MSC: general chemistry

41. ANS: E PTS: 1 DIF: easy REF: 13.6
OBJ: Use the Arrhenius equation. (Example 13.7)
TOP: rates of reaction | reaction rate KEY: Arrhenius equation
MSC: general chemistry

42. ANS: C PTS: 1 DIF: easy REF: 14.1
OBJ: Define dynamic equilibrium and chemical equilibrium. TOP: chemical equilibrium
MSC: general chemistry

43. ANS: E PTS: 1 DIF: easy REF: 14.1
OBJ: Define dynamic equilibrium and chemical equilibrium. TOP: chemical equilibrium

44. ANS: C PTS: 1 DIF: easy REF: 14.1
OBJ: Apply stoichiometry to an equilibrium mixture. (Example 14.1)
TOP: chemical equilibrium MSC: general chemistry

45. ANS: C PTS: 1 DIF: easy REF: 14.1
OBJ: Apply stoichiometry to an equilibrium mixture. (Example 14.1)
TOP: chemical equilibrium MSC: general chemistry

46. ANS: B PTS: 1 DIF: easy REF: 14.3
OBJ: Write equilibrium-constant expressions. (Example 14.2)
TOP: chemical equilibrium | equilibrium constant
KEY: definition of equilibrium constant Kc MSC: general chemistry

47. ANS: D PTS: 1 DIF: moderate REF: 14.2
OBJ: Write equilibrium-constant expressions. (Example 14.2)
TOP: chemical equilibrium | equilibrium constant
KEY: definition of equilibrium constant Kc MSC: general chemistry

48. ANS: A PTS: 1 DIF: easy REF: 14.2

OBJ: Obtain an equilibrium constant from reaction composition. (Example 14.3)
TOP: chemical equilibrium | using the equilibrium constant
KEY: calculating equilibrium concentrations MSC: general chemistry

49. ANS: A PTS: 1 DIF: easy REF: 14.2
OBJ: Obtain an equilibrium constant from reaction composition. (Example 14.3)
TOP: chemical equilibrium | equilibrium constant
KEY: the equilibrium constant Kp MSC: general chemistry

50. ANS: E PTS: 1 DIF: moderate REF: 14.2
OBJ: Obtain an equilibrium constant from reaction composition. (Example 14.3)
TOP: chemical equilibrium | equilibrium constant
KEY: definition of equilibrium constant Kc MSC: general chemistry

51. ANS: C PTS: 1 DIF: easy REF: 14.2
OBJ: Obtain Kc for a reaction that can be written as a sum of other reactions of known Kc values. TOP: chemical equilibrium | equilibrium constant
KEY: equilibrium constant for the sum of reactions MSC: general chemistry

52. ANS: A PTS: 1 DIF: moderate REF: 14.2
OBJ: Obtain Kc for a reaction that can be written as a sum of other reactions of known Kc values. TOP: chemical equilibrium | equilibrium constant

53. ANS: E PTS: 1 DIF: easy REF: 14.3
OBJ: Write Kc for a reaction with pure solids or liquids. (Example 14.4)
TOP: chemical equilibrium | equilibrium constant
KEY: heterogeneous and homogeneous equilibria MSC: general chemistry

54. ANS: C PTS: 1 DIF: easy REF: 14.4
OBJ: Give a qualitative interpretation of the equilibrium constant based on its value.
TOP: chemical equilibrium | using the equilibrium constant

55. ANS: D PTS: 1 DIF: easy REF: 14.4
OBJ: Give a qualitative interpretation of the equilibrium constant based on its value.
TOP: chemical equilibrium | using the equilibrium constant
KEY: qualitatively interpreting the equilibrium constant MSC: general chemistry

56. ANS: B PTS: 1 DIF: moderate REF: 14.5
OBJ: Define reaction quotient, Q.
TOP: chemical equilibrium | using the equilibrium constant
KEY: predicting the direction of reaction MSC: general chemistry

57. ANS: A PTS: 1 DIF: moderate REF: 14.5
OBJ: Describe the direction of reaction after comparing Q with Kc.
TOP: chemical equilibrium | using the equilibrium constant
KEY: predicting the direction of reaction MSC: general chemistry

58. ANS: A PTS: 1 DIF: moderate REF: 14.5
OBJ: Describe the direction of reaction after comparing Q with Kc.
TOP: chemical equilibrium | using the equilibrium constant

59. ANS: D PTS: 1 DIF: moderate REF: 14.6
OBJ: Obtain one equilibrium concentration given the others. (Example 14.6)
TOP: chemical equilibrium | using the equilibrium constant
KEY: calculating equilibrium concentrations MSC: general chemistry

60. ANS: B PTS: 1 DIF: moderate REF: 14.6

OBJ: Solve an equilibrium problem (involving a linear equation in x). (Example 14.7)
TOP: chemical equilibrium | using the equilibrium constant
KEY: calculating equilibrium concentrations MSC: general chemistry

61. ANS: C PTS: 1 DIF: moderate REF: 14.7
OBJ: State what happens to an equilibrium when a reactant or product is added or removed.
TOP: chemical equilibrium | Le Chatelier's principle

62. ANS: A PTS: 1 DIF: easy REF: 14.8
OBJ: Apply Le Châtelier’s principle when the pressure is altered. (Example 14.10)
TOP: chemical equilibrium | Le Chatelier's principle KEY: pressure change
MSC: general chemistry

63. ANS: D PTS: 1 DIF: easy REF: 14.8
OBJ: Apply Le Châtelier’s principle when the pressure is altered. (Example 14.10)
TOP: chemical equilibrium | Le Chatelier's principle KEY: pressure change
MSC: general chemistry

64. ANS: D PTS: 1 DIF: moderate REF: 14.8
OBJ: Describe the effect of a temperature change on chemical equilibrium.
TOP: chemical equilibrium | Le Chatelier's principle KEY: temperature change
MSC: general chemistry

65. ANS: E PTS: 1 DIF: easy REF: 14.8
OBJ: Apply Le Châtelier’s principle when the temperature is altered. (Example 14.11)
TOP: chemical equilibrium | Le Chatelier's principle KEY: temperature change
MSC: general chemistry

66. ANS: E PTS: 1 DIF: easy REF: 14.8
OBJ: Apply Le Châtelier’s principle when the temperature is altered. (Example 14.11)
TOP: chemical equilibrium | Le Chatelier's principle KEY: temperature change
MSC: general chemistry

67. ANS: A PTS: 1 DIF: easy REF: 14.8
OBJ: Describe how the optimum conditions for a reaction are chosen.
TOP: chemical equilibrium | Le Chatelier's principle MSC: general chemistry

68. ANS: A PTS: 1 DIF: moderate REF: 14.8
OBJ: Describe how the optimum conditions for a reaction are chosen.
TOP: chemical equilibrium | Le Chatelier's principle MSC: general chemistry