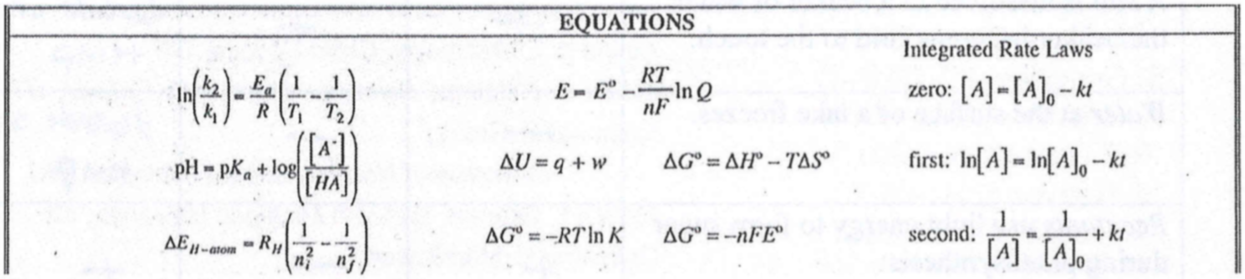


EQUATIONS

Integrated Rate Laws

$\ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$ $E = E^\circ - \frac{RT}{nF}\ln Q$ zero: $[A] = [A]_0 - kt$

$\mathrm{pH} = \mathrm{p}K_a + \log\left(\frac{[A^-]}{[HA]}\right)$ $\Delta U = q + w$ $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$ first: $\ln[A] = \ln[A]_0 - kt$

$\Delta E_{H\text{-}atom} = R_H\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)$ $\Delta G^\circ = -RT\ln K$ $\Delta G^\circ = -nFE^\circ$ second: $\frac{1}{[A]} = \frac{1}{[A]_0} + kt$

E = E° - (0.0592V/n)logQ, R = 8.3145 J/(mol K), F = 96,485 C/(mol e$^-$), 1A = 1C/s

Reduction half reaction	**E°(V)**
$Ag^+(aq) + e^- \rightarrow Ag(s)$	0.80
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	0.52
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	-0.76
$Mn^{2+}(aq) + 2e^- \rightarrow Mn(s)$	-1.180
$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$	-1.665

1. Choose the molecule or compound that exhibits dispersion forces as its strongest intermolecular force.
A) Cl_2
B) CO
C) HF
D) NaCl
E) All of these have intermolecular forces stronger than dispersion.

2. Which is expected to have the largest dispersion forces?
A) C_3H_8
B) $C_{12}H_{26}$
C) F_2
D) Be Cl_2

3. Choose the substance with the highest viscosity.
A) $(CH_3CH_2)_2CO$
B) $C_2H_4Cl_2$
C) $HOCH_2CH_2CH_2CH_2OH$
D) CF_4
E) C_6H_{14}

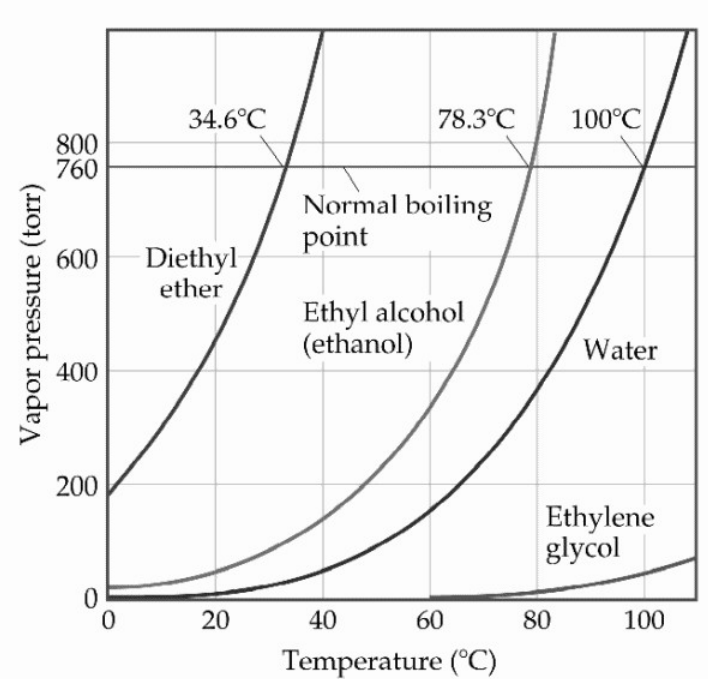
4. Place the following substances in order of **increasing** boiling point.

Ne Cl_2 O_2

A) Ne < Cl_2 < O_2
B) Cl_2 < O_2 < Ne
C) O_2 < Cl_2 < Ne

D) Cl_2 < Ne < O_2
E) Ne < O_2 < Cl_2

5. How much energy is required to vaporize 48.7 g of dichloromethane (CH_2Cl_2) at its boiling point, if its ΔH_{vap} is 31.6 kJ/mol?
A) 31.2 kJ
B) 6.49 kJ
C) 55.1 kJ
D) 15.4 kJ
E) 18.1 kJ



6. Based on the figure above, the boiling point of water under an external pressure of 0.316 atm is __________°C.
A) 70
B) 40
C) 60
D) 80
E) 90

7. Calculate the total quantity of heat required to convert 25.0 g of liquid $CCl_4(l)$ from 35.0°C to gaseous CCl_4 at 76.8°C (the normal boiling point for CCl_4). The specific heat of $CCl_4(l)$ is 0.857 J/(g · °C), its heat of fusion is 3.27 kJ/mol, and its heat of vaporization is 29.82 kJ/mol.
A) 0.896 kJ
B) 1.43 kJ
C) 5.74 kJ
D) 6.28 kJ

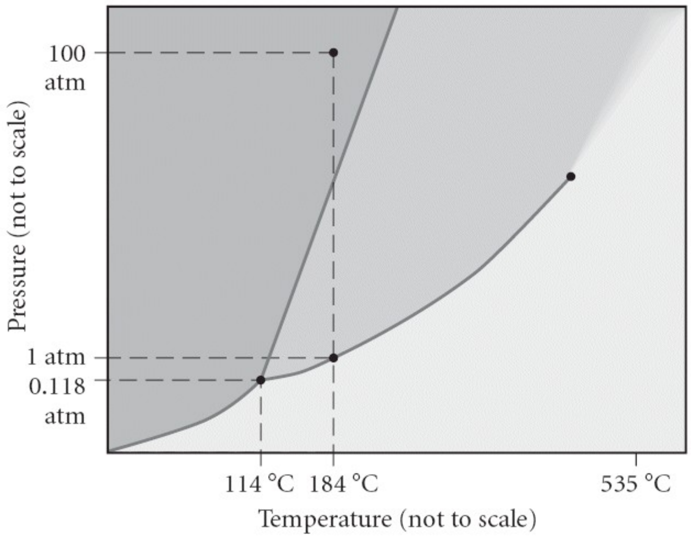
8. How much energy must be removed from a 125 g sample of benzene (molar mass= 78.11

g/mol) at 425.0 K to liquify the sample and lower the temperature to 335.0 K? The following physical data may be useful.

ΔH_{vap} = 33.9 kJ/mol
ΔH_{fus} = 9.8 kJ/mol
C_{liq} = 1.73 J/g°C
C_{gas} = 1.06 J/g°C
C_{sol} = 1.51 J/g°C
$T_{melting}$ = 279.0 K
$T_{boiling}$ = 353.0 K

A) 38.9 kJ
B) 95.4 kJ
C) 67.7 kJ
D) 54.3 kJ
E) 74.4 kJ

9. Consider the phase diagram below. If the dashed line at 1 atm of pressure is followed from 100 to 500°C, what phase changes will occur (in order of increasing temperature)?



A) condensation, followed by vaporization
B) sublimation, followed by deposition
C) vaporization, followed by deposition
D) fusion, followed by vaporization
E) No phase change will occur under the conditions specified.

10. Which of the following is considered an atomic solid?
A) Br_2
B) CsCl
C) N_2
D) Nb
E) None of these is an atomic solid.

11. Which of the following substances should have the highest melting point?
A) CO_2
B) SrS
C) Xe
D) F_2
E) MgO

12. A solution containing less than the equilibrium amount is called __________.
A) an unsaturated solution
B) a dilute solution
C) a supersaturated solution
D) a concentrated solution
E) a saturated solution

13. Give the term for the amount of solute in moles per kilogram of solvent.
A) molality
B) molarity
C) mole fraction
D) mole percent
E) mass percent

14. A solution is prepared by dissolving 49.3 g of KBr in enough water to form 473 mL of solution. Calculate the mass % of KBr in the solution if the density is 1.12 g/mL.
A) 10.4%
B) 8.57%
C) 10.1%
D) 11.7%
E) 9.31%

15. A solution is 0.0433 *m* LiF. What is the molarity of the solution if the density is 1.10 g/mL?
A) 0.0441 M
B) 0.0390 M
C) 0.0519 M
D) 0.0476 M
E) 0.0417 M

16. The boiling point elevation of an aqueous sucrose solution is found to be 0.39°C. What mass of sucrose (molar mass= 342.30 g/mol) would be needed to dissolve in 500.0 g of water?
K_b (water) = 0.512°C/*m*.
A) 261 g sucrose
B) 528 g sucrose
C) 762 g sucrose
D) 223 g sucrose
E) 130. g sucrose

17. A compound is found to have a molar mass of 598 g/mol. If 35.8 mg of the compound is dissolved in enough water to make 175 mL of solution at 25°C, what is the osmotic pressure of the resulting solution?

A) 3.42 torr
B) 6.36 torr
C) 5.01 torr
D) 5.99 torr
E) 8.36 torr

18. Choose the aqueous solution that has the highest boiling point. These are all solutions of nonvolatile solutes and you should assume ideal van't Hoff factors where applicable.
A) 0.100 *m* $NaNO_3$
B) 0.100 *m* Li_2SO_4
C) 0.200 *m* $C_3H_8O_3$
D) 0.060 *m* Na_3PO_4
E) They all have the same boiling point.

19. A solution is prepared by dissolving 7.00 g of glycerin ($C_3H_8O_3$) in 201 g of ethanol (C_2H_5OH). The freezing point of the solution is __________°C. The freezing point of pure ethanol is -114.6 °C at 1 atm. The molal-freezing-point-depression constant (K_f) for ethanol is 1.88 °C/m. The molar masses of glycerin and of ethanol are 92.1 g/mol and 46.1 g/mol, respectively.
A) -121.3
B) 0.752
C) -107.9
D) -113.8
E) -115.4

20. Write a balanced reaction for which the following rate relationships are true.

$$\text{Rate} = \frac{1}{2}\frac{\Delta[N_2]}{\Delta t} = \frac{\Delta[O_2]}{\Delta t} = -\frac{1}{2}\frac{\Delta[N_2O]}{\Delta t}$$

A) $\frac{1}{2} N_2 + O_2 \rightarrow \frac{1}{2} N_2O$
B) $2 N_2O \rightarrow 2 N_2 + O_2$
C) $N_2O \rightarrow N_2 + 2 O_2$
D) $\frac{1}{2} N_2O \rightarrow \frac{1}{2} N_2 + O_2$
E) $2 N_2 + O_2 \rightarrow 2 N_2O$

21. What is the overall order of the following reaction, given the rate law?

$$X + 2\,Y \rightarrow 4\,Z \qquad \text{Rate} = k[X][Y]$$

A) 3rd order
B) 5th order
C) 2nd order

D) 1st order
E) 0th order

22. What are the units of k in the following rate law?
Rate = k[X][Y]

A) $\frac{M}{s}$
B) Ms
C) $M^{-1}s^{-1}$
D) $\frac{M^2}{s}$
E) $\frac{s}{M^2}$
Answer: C
Diff: 2 Page Ref: 13.3

23. Determine the rate law and the value of k for the following reaction using the data provided.

$S_2O_8^{2-}(aq) + 3\ I^-(aq) \rightarrow 2\ SO_4^{2-}(g) + I_3^-(aq)$

$[S_2O_8^{2-}]_i$ (M)	$[I^-]_i$ (M)	Initial Rate ($M^{-1}s^{-1}$)
0.30	0.42	4.54
0.44	0.42	6.65
0.44	0.21	3.33

A) Rate = 120 $M^{-2}s^{-1}$ $[S_2O_8^{2-}]^2[I^-]$
B) Rate = 36 $M^{-1}s^{-1}$ $[S_2O_8^{2-}][I^-]$
C) Rate = 86 $M^{-2}s^{-1}$ $[S_2O_8^{2-}][I^-]^2$
D) Rate = 195 $M^{-3}s^{-1}$ $[S_2O_8^{2-}]^2[I^-]^2$
E) Rate = 23 $M^{-1/2}s^{-1}$ $[S_2O_8^{2-}][I^-]^{1/2}$

24. The half-life for the second-order decomposition of HI is 15.4 s when the initial concentration of HI is 0.67 M. What is the rate constant for this reaction?
A) $1.0 \times 10^{-2}\ M^{-1}s^{-1}$
B) $4.5 \times 10^{-2}\ M^{-1}s^{-1}$
C) $9.7 \times 10^{-2}\ M^{-1}s^{-1}$
D) $2.2 \times 10^{-2}\ M^{-1}s^{-1}$
E) $3.8 \times 10^{-2}\ M^{-1}s^{-1}$

25. Identify the rate-determining step.
A) the slowest step
B) the faster step
C) the fast step
D) always the last step

E) always the second step

26. Given the following proposed mechanism, predict the rate law for the overall reaction.

$A_2 + 2B \rightarrow 2AB$ (overall reaction)

Mechanism

A_2 $2A$	fast
$A + B \rightarrow AB$	slow

A) Rate = k[A][B]
B) Rate = k[A_2][B]
C) Rate = k[A_2][B]$^{1/2}$
D) Rate = k[A_2]
E) Rate = k [A_2]$^{1/2}$[B]

27. Carbon-14, which is present in all living tissue, radioactively decays via a first-order process. A one-gram sample of wood taken from a living tree gives a rate for carbon-14 decay of 13.6 counts per minute. If the half-life for carbon-14 is 5720 years, how old is a wood sample that gives a rate for carbon-14 decay of 11.9 counts per minute?
A) 5.3×10^2 yr
B) 7.6×10^2 yr
C) 1.1×10^3 yr
D) 9.4×10^3 yr

28. Which of the following statements is FALSE?
A) When K >> 1, the forward reaction is favored and essentially goes to completion.
B) When K << 1, the reverse reaction is favored and the forward reaction does not proceed to a great extent.
C) When K ≈ 1, neither the forward or reverse reaction is strongly favored, and about the same amount of reactants and products exist at equilibrium.
D) K >> 1 implies that the reaction is very fast at producing products.
E) None of the above.

29. The equilibrium constant is given for two of the reactions below. Determine the value of the missing equilibrium constant.

A(g) + B(g) AB(g)	$K_c = 0.24$
AB(g) + A(g) A_2B(g)	$K_c = 3.8$
2 A(g) + B(g) A_2B(g)	$K_c = ?$

A) 4.0
B) 0.91
C) 3.6
D) 16
E) 0.63

30. Calculate the value of $[N_2]_{eq}$ if $[H_2]_{eq} = 2.0$ M, $[NH_3]_{eq} = 0.5$ M, and $K_c = 2$.

$N_2(g) + 3\ H_2(g)$ ⍰ $2\ NH_3(g)$

A) 0.016 M
B) 0.031 M
C) 0.062 M
D) 0.40 M
E) 62.5 M

31. In a reaction mixture containing reactants and products, each at a concentration of 1M, what is the value of Q?
A) -1
B) 1
C) ∞
D) 0
E) It cannot be determined without concentrations.

32. Consider the following reaction, equilibrium concentrations, and equilibrium constant at a particular temperature. Determine the equilibrium concentration of $SO_3(g)$.

$2\ SO_2(g) + O_2(g)$ ⍰ $2\ SO_3(g)$ $\qquad K_c = 1.7 \times 10^8$

$[SO_3]_{eq} = 0.0034$ M $\qquad [O_2]_{eq} = 0.0018$ M

A) 2.8×10^{13} M
B) 1.88 M
C) 6.1×10^{-6} M
D) 1.0×10^{3} M
E) 1.4 M

33. Identify the change that will always shift the equilibrium to the right.
A) remove reactant
B) increase product
C) remove product
D) increase pressure
E) increase volume

34. Consider the following reaction at equilibrium. What effect will increasing the temperature have on the system?

$Fe_3O_4(s) + CO(g)$ ⍰ $3\ FeO(s) + CO_2(g)$ $\qquad \Delta H° = +35.9$ kJ

A) The reaction will shift to the left in the direction of reactants.
B) The equilibrium constant will increase.
C) The equilibrium constant will decrease.

D) No effect will be observed.
E) The reaction will shift to the right in the direction of products.

35. Which of the following is an Arrhenius acid?
A) H_2SO_4
B) LiOH
C) NH_2CH_3
D) CH_3CH_3
E) More than one of these is an Arrhenius acid.

36. Which of the following species is amphoteric?
A) CO_3^{2-}
B) HF
C) NH_4^+
D) HPO_4^{2-}
E) None of the above are amphoteric.

37. Identify the diprotic acid.
A) HNO_3
B) HCl
C) CH_3COOH
D) H_2SO_4
E) $HClO_4$

38. The stronger the acid, then which of the following is TRUE?
A) The stronger the conjugate acid.
B) The stronger the conjugate base.
C) The weaker the conjugate base.
D) The weaker the conjugate acid.
E) None of the above.

39. Which of the following statements is TRUE?
A) A strong acid is composed of a proton and an anion that have a very strong attraction for one another.
B) A weak base is composed of a cation and an anion with a very weak attraction between them.
C) A strong acid has a strong conjugate base.
D) The conjugate base of a very weak acid is stronger than the conjugate base of a strong acid.
E) None of the above statements are true.

40. What is the concentration of hydroxide ions in pure water at 30.0°C, if K_W at this temperature is 1.47×10^{-14}?
A) 1.00×10^{-7} M
B) 1.30×10^{-7} M
C) 1.47×10^{-7} M
D) 8.93×10^{-8} M
E) 1.21×10^{-7} M

41. Calculate the pOH of a solution that contains 3.9 x 10^{-4} M H_3O^+ at 25°C.
A) 4.59
B) 3.31
C) 10.59
D) 9.14
E) 0.59

42. Determine the pH of a 0.023 M HNO_3 solution.
A) 12.36
B) 3.68
C) 1.64
D) 2.30
E) 2.49

43. Determine the [H_3O^+] in a 0.265 M HClO solution. The K_a of HClO is 2.9 × 10^{-8}.
A) 1.1 × 10^{-10} M
B) 7.7 × 10^{-9} M
C) 1.3 × 10^{-6} M
D) 4.9 × 10^{-4} M
E) 8.8 × 10^{-5} M

44. Determine the pH of a 0.188 M NH_3 solution at 25°C. The K_b of NH_3 is 1.76 × 10^{-5}.
A) 5.480
B) 2.740
C) 8.520
D) 11.260
E) 12.656

45. Determine the pH of a 0.62 M NH_4NO_3 solution at 25°C. The K_b for NH_3 is 1.76 × 10^{-5}.
A) 2.48
B) 9.27
C) 11.52
D) 4.73
E) 9.45

46. Determine the concentration of CO_3^{2-} ions in a 0.18 M H_2CO_3 solution. Carbonic acid is a diprotic acid whose K_{a1} = 4.3 × 10^{-7} and K_{a2} = 5.6 × 10^{-11}.
A) 2.8 × 10^{-4} M
B) 3.2 × 10^{-6} M
C) 5.6 × 10^{-11} M
D) 4.3 × 10^{-7} M
E) 6.9 × 10^{-8} M

47. What is the hydroxide ion concentration and the pH for a hydrochloric acid solution that has a hydronium ion concentration of 1.50 × 10^{-2} M?

A) 6.67×10^{-12} M, 2.82
B) 6.67×10^{-12} M, 11.18
C) 6.67×10^{-13} M, 1.82
D) 6.67×10^{-13} M, 12.17

48. Calculate the pH of a 0. 080 M carbonic acid solution, $H_2CO_3(aq)$, that has the stepwise dissociation constants $K_{a1} = 4.3 \times 10^{-7}$ and $K_{a2} = 5.6 \times 10^{-11}$.
A) 1.10
B) 3.73
C) 6.37
D) 10.25

49. If the pKa of $HCHO_2$ is 3.74 and the pH of an $HCHO_2/NaCHO_2$ solution is 3.11, which of the following is TRUE?
A) $[HCHO_2] < [NaCHO_2]$
B) $[HCHO_2] = [NaCHO_2]$
C) $[HCHO_2] << [NaCHO_2]$
D) $[HCHO_2] > [NaCHO_2]$
E) It is not possible to make a buffer of this pH from $HCHO_2$ and $NaCHO_2$.

50. Calculate the pH of a buffer that is 0.020 M HF and 0.040 M LiF. The K_a for HF is 3.5×10^{-4}.
A) 2.06
B) 4.86
C) 3.16
D) 3.46
E) 3.76

51. A 1.00 L buffer solution is 0.250 M in HF and 0.250 M in NaF. Calculate the pH of the solution after the addition of 100.0 mL of 1.00 M HCl. The K_a for HF is 3.5×10^{-4}.
A) 3.09
B) 4.11
C) 3.82
D) 3.46
E) 2.78
52. Which of the following is TRUE?
A) The equivalence point is where the amount of acid equals the amount of base during any acid-base titration.
B) At the equivalence point, the pH is always 7.
C) An indicator is not pH sensitive.
D) A titration curve is a plot of pH vs. the [base]/[acid] ratio.
E) None of the above are true.

53. A 100.0 mL sample of 0.20 M HF is titrated with 0.10 M KOH. Determine the pH of the solution after the addition of 100.0 mL of KOH. The K_a of HF is 3.5×10^{-4}.
A) 2.08

B) 3.15
C) 4.33
D) 3.46
E) 4.15

54. A 100.0 mL sample of 0.20 M HF is titrated with 0.10 M KOH. Determine the pH of the solution after the addition of 400.0 mL of KOH. The K_a of HF is 3.5×10^{-4}.
A) 13.08
B) 12.60
C) 13.85
D) 12.30
E) 12.78

55. Give the expression for the solubility product constant for $PbCl_2$.
A) $\dfrac{[Pb^{2+}][Cl^-]^2}{[PbCl_2]}$
B) $\dfrac{[PbCl_2]}{[Pb^{2+}][Cl^-]^2}$
C) $[Pb^{2+}][Cl^-]^2$
D) $\dfrac{[Pb^{2+}]^2[Cl^-]}{[PbCl_2]}$
E) $[Pb^{2+}]^2[Cl^-]$

56. Give the equation for an unsaturated solution in comparing Q with K_{sp}.
A) $Q > K_{sp}$
B) $Q < K_{sp}$
C) $Q = K_{sp}$
D) $Q \neq K_{sp}$
E) none of the above

57. A solution containing $CaCl_2$ is mixed with a solution of $Li_2C_2O_4$ to form a solution that is 2.1×10^{-5} M in calcium ion and 4.75×10^{-5} M in oxalate ion. What will happen once these solutions are mixed? K_{sp} $(CaC_2O_4) = 2.3 \times 10^{-9}$.
A) A precipitate will form since $Q > K_{sp}$ for calcium oxalate.
B) Nothing will happen since both calcium chloride and lithium oxalate are soluble compounds.
C) Nothing will happen since calcium oxalate is extremely soluble.
D) Nothing will happen since $K_{sp} > Q$ for all possible precipitants.
E) There is not enough information to determine.

58. Calculate the K_{sp} for silver sulfite if the solubility of Ag_2SO_3 in pure water is 4.6×10^{-3} g/L.
A) 3.8×10^{-15}
B) 1.5×10^{-14}

C) 2.4×10^{-10}
D) 4.8×10^{-10}

59. Which of the following processes shows a decrease in entropy of the system?
A) $2\ NO(g) + O_2(g) \rightarrow 2\ NO_2(g)$
B) $COCl_2(g) \rightarrow CO(g) + Cl_2(g)$
C) $CH_3OH(l) \rightarrow CO(g) + 2H_2(g)$
D) $NaClO_3(s) \rightarrow Na^+(aq) + ClO_3^-(aq)$
E) None of the above will show a decrease in entropy.

60. Consider a reaction that has a positive ΔH and a positive ΔS. Which of the following statements is TRUE?
A) This reaction will be spontaneous only at low temperatures.
B) This reaction will be spontaneous at all temperatures.
C) This reaction will be nonspontaneous at all temperatures.
D) This reaction will be nonspontaneous only at low temperatures.
E) It is not possible to determine without more information.

61. Above what temperature does the following reaction become nonspontaneous?

$$FeO(s) + CO(g) \rightarrow CO_2(g) + Fe(s) \qquad \Delta H = -11.0\ kJ;\ \Delta S = -17.4\ J/K$$

A) 632 K
B) 298 K
C) 191 K
D) This reaction is nonspontaneous at all temperatures.
E) This reaction is spontaneous at all temperatures.

62. Determine $\Delta G°_{rxn}$ using the following information.

$$FeO(s) + CO(g) \rightarrow Fe(s) + CO_2(g) \quad \Delta H° = -11.0\ kJ;\ \Delta S° = -17.4\ J/K$$

A) +191.0 kJ
B) -5.8 kJ
C) +1.6 kJ
D) -6.4 kJ
E) +89.5 kJ

63. What is true if ln K is positive?
A) ΔG^o_{rxn} is positive and the reaction is spontaneous in the forward direction.
B) ΔG^o_{rxn} is negative and the reaction is spontaneous in the forward direction.
C) ΔG^o_{rxn} is negative and the reaction is spontaneous in the reverse direction.
D) ΔG^o_{rxn} is positive and the reaction is spontaneous in the reverse direction.
E) ΔG^o_{rxn} is zero and the reaction is at equilibrium.

64. What element is being reduced in the following redox reaction?

$MnO_4^-(aq) + H_2C_2O_4(aq) \rightarrow Mn^{2+}(aq) + CO_2(g)$

A) C
B) O
C) Mn
D) H

65. Balance the following redox reaction if it occurs in basic solution. What are the coefficients in front of Br_2 and OH^- in the balanced reaction?

$Br_2(l) \rightarrow BrO_3^-(aq) + Br^-(aq)$

A) $Br_2 = 1$, $OH^- = 2$
B) $Br_2 = 2$, $OH^- = 5$
C) $Br_2 = 3$, $OH^- = 3$
D) $Br_2 = 3$, $OH^- = 6$
E) $Br_2 = 1$, $OH^- = 6$

66. Define a salt bridge.
A) A pathway, composed of salt water, that ions pass through.
B) A pathway in which no ions flow.
C) A pathway between the cathode and anode in which ions are reduced.
D) A pathway between the cathode and anode in which ions are oxidized.
E) A pathway by which counterions can flow between the half-cells without the solutions in the half-cell totally mixing.

67. What is the oxidizing agent in the redox reaction represented by the following cell notation?

$Ni(s)$ ⍰ $Ni^{2+}(aq)$ || $Ag^+(aq)$ ⍰ $Ag(s)$

A) $Ni(s)$
B) $Ni^{2+}(aq)$
C) $Ag^+(aq)$
D) $Ag(s)$
E) Pt

68. Identify the characteristics of a spontaneous reaction.
A) $\Delta G^\circ < 0$
B) $\Delta E^\circ_{cell} > 0$
C) $K > 1$
D) all of the above
E) none of the above

69. Look up half-cell potentials and calculate ΔG° for the following balanced redox reaction.

$3\ I_2(s) + 2\ Fe(s) \rightarrow 2\ Fe^{3+}(aq) + 6\ I^-(aq)$

A) -1.1 x 10^2 kJ
B) +4.9 x 10^1 kJ
C) -9.7 x 10^1 kJ
D) +2.3 x 10^2 kJ
E) -3.3 x 10^2 kJ

70. What is the shorthand notation that represents the following galvanic cell reaction?
$Pb(s) + Cu(NO_3)_2(aq) \rightarrow Pb(NO_3)_2(aq) + Cu(s)$

A) $Pb(s)$ ⍰ $Pb^{2+}(aq)$ ⍰⍰ $Cu^{2+}(aq)$ ⍰ $Cu(s)$
B) $Cu(s)$ ⍰ $Cu^{2+}(aq)$ ⍰⍰ $Pb^{2+}(aq)$ ⍰ $Pb(s)$
C) $Pb(s)$ ⍰ $NO_3^-(aq)$ ⍰⍰ $NO_3^-(aq)$ ⍰ $Cu(s)$
D) $Cu(s)$ ⍰ $Cu(NO_3)_2(aq)$ ⍰⍰ $Pb(NO_3)_2(aq)$ ⍰ $Pb(s)$