EQUATIONS					
$\ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R} \left(\frac{1}{T_1} - \frac{1}{T_2}\right)$	$E = E^{o} - \frac{RT}{nF} \ln Q$		Integrated Rate Laws zero: $[A] = [A]_0 - kt$		
$pH = pK_a + \log\left(\frac{\left[A^{-}\right]}{\left[HA\right]}\right)$	$\Delta U = q + w$	$\Delta G^{\circ} = \Delta H^{\circ} - T \Delta S^{\circ}$	first: $\ln[A] = \ln[A]_0 - kt$		
$\Delta E_{H-atom} = R_H \left(\frac{1}{n_i^2} - \frac{1}{n_f^2} \right)$	$\Delta G^{\rm o} = -RT \ln K$	$\Delta G^{\circ} = -nFE^{\circ}$	second: $\frac{1}{[A]} = \frac{1}{[A]_0} + kt$		

 $E = E^{\circ} - (0.0592V/n)\log Q$, 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) Cl₂

B) CO

C) HF

D) NaCl

E) All of these have intermolecular forces stronger than dispersion.

Answer: A

Diff: 2 Page Ref: 11.3

2. Which is expected to have the largest dispersion forces?

A) C3H8

B) C12H26

C) F2

D) Be Cl₂

Answer: B

Diff: 2 Page Ref: 11.3

3. Choose the substance with the highest viscosity.
A) (CH₃CH₂)₂CO
B) C₂H₄Cl₂
C) HOCH₂CH₂CH₂CH₂CH₂OH
D) CF₄
E) C₆H₁₄
Answer: C
Diff: 2 Page Ref: 11.4

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



5. How much energy is required to vaporize 48.7 g of dichloromethane (CH₂Cl₂) 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 Answer: E Diff: 3 Page Ref: 11.5





7. Calculate the total quantity of heat required to convert 25.0 g of liquid CCl4(*l*) from 35.0°C to gaseous CCl4 at 76.8°C (the normal boiling point for CCl4). The specific heat of CCl4(*l*) is 0.857 J/(g \cdot °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 Answer: C Diff: 4 Page Ref: 11.7

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.

 $\Delta H_{vap} = 33.9 \text{ kJ/mol}$ $\Delta H_{fus} = 9.8 \text{ kJ/mol}$ $C_{liq} = 1.73 \text{ J/g}^{\circ}\text{C}$ $C_{gas} = 1.06 \text{ J/g}^{\circ}\text{C}$ $C_{sol} = 1.51 \text{ J/g}^{\circ}\text{C}$ $T_{melting} = 279.0 \text{ K}$ $T_{boiling} = 353.0 \text{ K}$ A) 38.9 kJ B) 95.4 kJ C) 67.7 kJ D) 54.3 kJ E) 74.4 kJ Answer: C

Page Ref: 11.7

Diff: 5

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)?



E) a saturated solution

Answer: A Diff: 2 Page Ref: 12.4

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
Answer: A
Diff: 1 Page Ref: 12.5

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%
Answer: E
Diff: 3 Page Ref: 12.5

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
Answer: D
Diff: 4 Page Ref: 12.5

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? Kb (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
Answer: E
Diff: 3 Page Ref: 12.6

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 Answer: B Diff: 3 Page Ref: 12.6

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* NaNO3
B) 0.100 *m* Li₂SO4
C) 0.200 *m* C₃H₈O3
D) 0.060 *m* Na₃PO4
E) They all have the same boiling point.
Answer: B
Diff: 1 Page Ref: 12.7

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

A) -121.3 B) 0.752 C) -107.9 D) -113.8 E) -115.4 Answer: E Diff: 4 Page Ref: 12.6

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

$$Rate = \frac{1}{2} \frac{\Delta[N_2]}{\Delta t} = \frac{\Delta[O_2]}{\Delta t} = -\frac{1}{2} \frac{\Delta[N_2O]}{\Delta t}$$
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) $2 N_2 + O_2 \rightarrow 2 N_2O$
Answer: B
Diff: 2 Page Ref: 13.2

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

 $X + 2 Y \rightarrow 4 Z$ Rate = k[X][Y]

A) 3rd order
B) 5th order
C) 2nd order
D) 1st order
E) 0th order
Answer: C
Diff: 2 Page Ref: 13.3

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

A) $\frac{M}{s}$ B) Ms C) M-1s-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.

 $S_2O_8^{2-}(aq) + 3 I^{-}(aq) \rightarrow 2 SO_4^{2-}(g) + I_3^{-}(aq)$ $[S_2O_8^{2-}]_i(M)$ Initial Rate (M-1s-1) [I⁻]_i (M) 0.30 0.42 4.54 0.44 0.42 6.65 0.44 0.21 3.33 A) Rate = $120 \text{ M} \cdot 2\text{s} \cdot 1 [\text{S}_2 \text{O}_8^2 -]^2[\text{I}^-]$ B) Rate = $36 \text{ M} \cdot 1 \text{ s} \cdot 1 \text{ [S}_2 \text{ O}_8 \text{ }^2 \text{][I^-]}$ C) Rate = 86 M-2s-1 $[S_2O_82^-][I^-]^2$ D) Rate = $195 \text{ M} \cdot 3\text{s} \cdot 1 [\text{S}_2\text{O}_8^2 -]^2[\text{I}_2^2]^2$ E) Rate = 23 M-1/2s-1 [S₂O₈2-][I-]1/2 Answer: B Page Ref: 13.3 Diff: 3

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) $1.0 \times 10^{-2} \text{ M}^{-1}\text{s}^{-1}$ B) $4.5 \times 10^{-2} \text{ M}^{-1}\text{s}^{-1}$ C) $9.7 \times 10^{-2} \text{ M}^{-1}\text{s}^{-1}$ D) $2.2 \times 10^{-2} \text{ M}^{-1}\text{s}^{-1}$ E) $3.8 \times 10^{-2} \text{ M}^{-1}\text{s}^{-1}$ Answer: C Diff: 2 Page Ref: 13.4

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
Answer: A
Diff: 1 Page Ref: 13.5

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

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

 $\frac{\text{Mechanism}}{A_2 \quad 2A} \qquad \text{fast} \\ A + B \rightarrow AB \qquad \text{slow}$ A) Rate = k[A][B] B) Rate = k[A2][B] C) Rate = k[A2][B]^{1/2} D) Rate = k[A2] E) Rate = k [A2]^{1/2}[B] Answer: E Diff: 3 Page Ref: 13.6

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 Answer: C Diff: 3 Page Ref: 13.4

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 \ll 1, the reverse reaction is favored and the forward reaction does not proceed to a great extent.

C) When $K \approx 1$, 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.Answer: DDiff: 1 Page Ref: 14.3

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

 $\begin{array}{cccc} A(g) + B(g) & AB(g) & Kc = 0.24 \\ AB(g) + A(g) & A2B(g) & K_c = 3.8 \\ 2 & A(g) + B(g) & A2B(g) & K_c = ? \end{array}$ A) 4.0 B) 0.91 C) 3.6 D) 16 E) 0.63 Answer: B Diff: 2 Page Ref: 14.3

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 Answer: A Diff: 4 Page Ref: 14.6

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.
Answer: B

Diff: 1 Page Ref: 14.7

32. Consider the following reaction, equilibrium concentrations, and equilibrium constant at a particular temperature. Determine the equilibrium concentration of SO₃(g).

 $2 \text{ SO}_2(g) + \text{O}_2(g)$ $2 \text{ SO}_3(g)$ $K_c = 1.7 \times 10^8$ [SO3]eq = 0.0034 M [O2]eq = 0.0018 M A) 2.8 x 10¹³ M
B) 1.88 M
C) 6.1 x 10⁻⁶ M
D) 1.0 x 10³ M
E) 1.4 M
Answer: C
Diff: 3 Page Ref: 14.8

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
Answer: C
Diff: 2 Page Ref: 14.9

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

 $Fe_3O_4(s) + CO(g) = 3 FeO(s) + CO_2(g) = \Delta H^\circ = +35.9 \text{ kJ}$

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.

Answer: E

Diff: 2 Page Ref: 14.9

35. Which of the following is an Arrhenius acid?

A) H₂SO₄

B) LiOH

C) NH₂CH₃

D) CH₃CH₃

E) More than one of these is an Arrhenius acid.

Answer: A

Diff: 1 Page Ref: 15.3

36. Which of the following species is amphoteric?

A) CO3²⁻
B) HF
C) NH4⁺
D) HPO4²⁻
E) None of the above are amphoteric.
Answer: D

Diff: 1 Page Ref: 15.3

37. Identify the diprotic acid.
A) HNO3
B) HC1
C) CH3COOH
D) H2SO4
E) HClO4
Answer: D
Diff: 1 Page Ref: 15.3

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.

Answer: C

Diff: 1 Page Ref: 15.4

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.

Answer: D

Diff: 1 Page Ref: 15.4

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 Answer: E Diff: 2 Page Ref: 15.5

41. Calculate the pOH of a solution that contains 3.9 x 10-4 M H₃O⁺ at 25°C.
A) 4.59
B) 3.31
C) 10.59
D) 9.14

E) 0.59 Answer: C Diff: 2 Page Ref: 15.5

42. Determine the pH of a 0.023 M HNO3 solution. A) 12.36 B) 3.68 C) 1.64 D) 2.30 E) 2.49 Answer: C Diff: 2 Page Ref: 15.5 43. Determine the [H₃O⁺] 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 Answer: E Diff: 3 Page Ref: 15.6 44. Determine the pH of a 0.188 M NH₃ solution at 25°C. The K_b of NH₃ is 1.76×10^{-5} . A) 5.480 B) 2.740 C) 8.520 D) 11.260 E) 12.656 Answer: D Diff: 3 Page Ref: 15.7

45. Determine the pH of a 0.62 M NH4NO3 solution at 25°C. The Kb for NH3 is 1.76 × 10⁻⁵. A) 2.48 B) 9.27 C) 11.52 D) 4.73 E) 9.45 Answer: D Diff: 3 Page Ref: 15.8

46. Determine the concentration of CO₃²⁻ ions in a 0.18 M H₂CO₃ solution. Carbonic acid is a diprotic acid whose $K_{a1} = 4.3 \times 10^{-7}$ and $K_{a2} = 5.6 \times 10^{-11}$. 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 Answer: C Diff: 5 Page Ref: 15.9

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 Answer: C Diff: 3 Page Ref: 15.5

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 Answer: B Diff: 5 Page Ref: 15.9

49. If the pKa of HCHO₂ is 3.74 and the pH of an HCHO₂/NaCHO₂ solution is 3.11, which of the following is TRUE?
A) [HCHO₂] < [NaCHO₂]
B) [HCHO₂] = [NaCHO₂]
C) [HCHO₂] << [NaCHO₂]
D) [HCHO₂] > [NaCHO₂]
E) It is not possible to make a buffer of this pH from HCHO₂ and NaCHO₂.
Answer: D
Diff: 2 Page Ref: 16.2

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 Answer: E Diff: 3 Page Ref: 16.2

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 Answer: A Diff: 4 Page Ref: 16.2

52. Which of the following is TRUE?

A) The equivalence point is where the amount of acid equals the amount of base during any acidbase 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.

Answer: A

Diff: 1 Page Ref: 16.4

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 Answer: D Diff: 3 Page Ref: 16.4

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 Answer: B Diff: 4 Page Ref: 16.4

55. Give the expression for the solubility product constant for PbCl₂.

A)
$$\frac{[Pb^{2+}][Cl^{-}]^{2}}{[PbCl_{2}]}$$

B)
$$\frac{[PbCl_{2}]}{[Pb^{2+}][Cl^{-}]^{2}}$$

C)
$$[Pb^{2+}][Cl^{-}]^{2}$$

D)
$$\frac{[Pb^{2+}]^{2}[Cl^{-}]}{[PbCl_{2}]}$$

E) [Pb²⁺]²[Cl⁻] Answer: C Diff: 2 Page Ref: 16.5

56. Give the equation for an unsaturated solution in comparing Q with Ksp.

A) $Q > K_{sp}$ B) $Q < K_{sp}$ C) $Q = K_{sp}$ D) $Q \neq K_{sp}$ E) none of the above Answer: B Diff: 1 Page Ref: 16.6

57. A solution containing CaCl₂ is mixed with a solution of Li₂C₂O₄ 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} (CaC₂O₄) = 2.3×10^{-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.

Answer: D

Diff: 2 Page Ref: 16.6

58. Calculate the K_{SP} for silver sulfite if the solubility of Ag₂SO₃ in pure water is

 $\begin{array}{ll} 4.6 \times 10^{-3} \text{ g/L.} \\ \text{A) } 3.8 \times 10^{-15} \\ \text{B) } 1.5 \times 10^{-14} \\ \text{C) } 2.4 \times 10^{-10} \\ \text{D) } 4.8 \times 10^{-10} \\ \text{Answer: B} \\ \text{Diff: 3} & \text{Page Ref: 16.5} \end{array}$

59. Which of the following processes shows a decrease in entropy of the system?
A) 2 NO(g) + O₂(g) → 2 NO₂(g)
B) COCl₂(g) → CO(g) + Cl₂(g)
C) CH₃OH(l) → CO(g) + 2H₂(g)
D) NaClO₃(s) →Na⁺(aq) + ClO₃-(aq)
E) None of the above will show a decrease in entropy.
Answer: A

Diff: 2 Page Ref: 17.3

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.

Answer: D

Diff: 2 Page Ref: 17.5

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

 $FeO(s) + CO(g) \rightarrow CO_2(g) + Fe(s) \qquad \Delta H = -11.0 \text{ kJ}; \ \Delta S = -17.4 \text{ J/K}$ 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.
Answer: A
Diff: 3 Page Ref: 17.5

62. Determine ΔG°_{rxn} using the following information.

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

A) +191.0 kJ B) -5.8 kJ C) +1.6 kJ D) -6.4 kJ E) +89.5 kJ Answer: B Diff: 3 Page Ref: 17.7

63. What is true if ln K is positive?

A) ΔGo_{rxn} is positive and the reaction is spontaneous in the forward direction.

B) ΔGo_{rxn} is negative and the reaction is spontaneous in the forward direction.

C) ΔGo_{rxn} is negative and the reaction is spontaneous in the reverse direction.

D) ΔGo_{rxn} is positive and the reaction is spontaneous in the reverse direction.

E) ΔG_{rxn}^{o} is zero and the reaction is at equilibrium.

Answer: B

Diff: 1 Page Ref: 17.9

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

 $MnO4^{-}(aq) + H_2C_2O4(aq) \rightarrow Mn^{2+}(aq) + CO_2(g)$

A) C B) O C) Mn D) H Answer: C Diff: 2 Page Ref: 18.2

65. Balance the following redox reaction if it occurs in basic solution. What are the coefficients in front of Br₂ 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) $Br_2 = 1$, $OH^- = 6$ Answer: D Diff: 4 Page Ref: 18.2

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.

Answer: E

Diff: 1 Page Ref: 18.3

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

Ni(s) Ni²⁺(aq) || Ag⁺(aq) Ag(s)

A) Ni(s) B) $Ni^{2+}(aq)$ C) $Ag^{+}(aq)$ D) Ag(s)E) Pt Answer: C Diff: 1 Page Ref: 18.4 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 Answer: D Diff: 2 Page Ref: 18.4

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

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

A) $-1.1 \times 10^2 \text{ kJ}$ B) $+4.9 \times 10^1 \text{ kJ}$ C) $-9.7 \times 10^1 \text{ kJ}$ D) $+2.3 \times 10^2 \text{ kJ}$ E) $-3.3 \times 10^2 \text{ kJ}$ Answer: E Diff: 3 Page Ref: 18.5

70. What is the shorthand notation that represents the following galvanic cell reaction? Pb(s) + Cu(NO₃)₂(aq) \rightarrow Pb(NO₃)₂(aq) + Cu(s) A) Pb(s) Pb²⁺(aq) Cu²⁺(aq) Cu(s) B) Cu(s) Cu²⁺(aq) Pb²⁺(aq) Pb(s) C) Pb(s) NO₃-(aq) NO₃-(aq) Cu(s) D) Cu(s) Cu(NO₃)₂(aq) Pb(NO₃)₂(aq) Pb(s) Answer: A Diff: 3 Page Ref: 18.3