

Name _____

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

- 1) Will a precipitate be observed if 0.10 mol Ag^+ and 0.001 mol SO_4^{2-} are added to make 1.0 L of solution? ($K_{\text{sp}} = 1.4 \times 10^{-5}$)
- A) Yes, because $Q > K_{\text{sp}}$.
 - B) No, because $Q > K_{\text{sp}}$.
 - C) Yes, because $Q < K_{\text{sp}}$.
 - D) No, because $Q < K_{\text{sp}}$.
 - E) More information is needed to answer this question.

Answer: D

- 2) At 25.0°C the enthalpy of vaporization of water (ΔH_{vap}) is 44.0 kJ/mol and the vapor pressure is 23.8 mm Hg. Calculate the vapor pressure of water at 50.0°C, in mm Hg.
- A) 6.02 B) 147 C) 58.2 D) 564 E) 94.1

Answer: E

- 3) Which of the following describes what happens to the solubility of a slightly soluble ionic compound when a common ion is added to the solution?
- A) More of the ionic compound dissolves.
 - B) The solubility of the ionic compound is increased.
 - C) There is no effect on the solubility of the ionic compound.
 - D) The solubility of the ionic compound is reduced.
 - E) The ionic compound dissolves more rapidly.

Answer: D

- 4) A saturated solution of AB_2 contains 8.60×10^{-4} moles AB_2 per liter. Determine K_{sp} .
- A) 6.36×10^{-10}
B) 7.40×10^{-7}
C) 1.27×10^{-9}
D) 1.48×10^{-6}
E) 2.54×10^{-9}

Answer: E

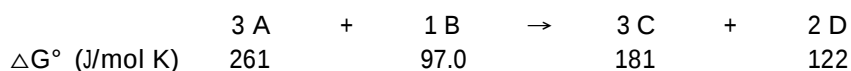
- 5) In the plot of $\ln(k)$ versus $1/T$ for a first order reaction, the frequency factor (A) can be determined by
- A) the negative of the slope of the line times R.
 - B) the intercept of the x-axis.
 - C) the slope of the line times R.
 - D) the slope of the line.
 - E) the intercept on the y-axis.

Answer: E

- 6) The vapor pressure of acetone is 400. mm Hg at 25°C, and $\Delta H_{\text{vap}} = 32.0$ kJ/mol. What is the temperature (°C) at which the vapor pressure of acetone is 550. mm Hg?
- A) 45 B) 33 C) 49 D) 39 E) 58

Answer: B

7) Given the values of ΔG° shown below, determine the value of ΔG° for the reaction.



- A) 101 B) -93.0 C) 93.0 D) -55.0 E) 1670

Answer: B

8) At 50°C, the solubility of silver chloride, AgCl, is 5.2×10^{-4} g/100 mL. Calculate the K_{sp} at this temperature.

- A) 7.6×10^8 B) 1.8×10^{-10} C) 4.0×10^{-5} D) 1.0×10^{-8} E) 1.3×10^{-9}

Answer: E

9) Which of the following mixtures/solutions would be a buffer solution?

- A) 25 mL 1 M NaOH + 50 mL 1 M CH_3COOH
 B) 25 mL 1 M NaOH + 50 mL 1 M NH_3
 C) 50 mL 1 M HCl + 50 mL 1 M NH_3
 D) 50 mL 1 M HCl + 50 mL 1 M NaOH
 E) none of these

Answer: A

10) Refer to the information in Figure 1. What is the predicted rate law for Mechanism II?

Two mechanisms proposed for the following reaction of nitrogen dioxide with carbon monoxide are shown below. Use this information to answer the following questions.

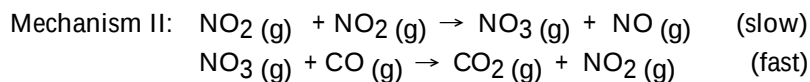
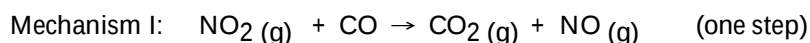
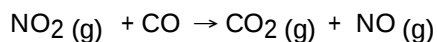
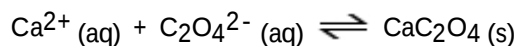


Figure 1

- A) rate = $k[\text{NO}_2]$
 B) rate = $k[\text{NO}_2]^2$
 C) rate = $k[\text{NO}_2]^2[\text{CO}]$
 D) rate = $k[\text{NO}_2][\text{CO}]$
 E) rate = $k[\text{NO}_3][\text{CO}]$

Answer: B

11) The addition of large quantities of $\text{C}_2\text{O}_4^{2-}$ to a solution of Ca^{2+} causes:



- A) precipitation of CaC_2O_4 .
- B) K_{sp} to increase.
- C) an increase in $[\text{Ca}^{2+}]$.
- D) precipitation of Ca^{2+} .
- E) K_{sp} to decrease.

Answer: A

12) Which process is accompanied by a decrease in entropy for the system?

- A) water evaporates
- B) ethanol condenses
- C) dry ice sublimates
- D) wax melts
- E) sodium chloride dissolves

Answer: B

13) In the titration of 20.0 mL of 0.200 M HOBr with 0.100 M NaOH, what is the pH at the equivalence point?

(K_{a} HOBr = 2.5×10^{-9})

- A) 10.86
- B) 7.00
- C) 4.40
- D) 3.29
- E) 10.71

Answer: E

14) At 300 K, for equilibrium in the reaction $\text{A} + \text{B} \leftrightarrow \text{C} + \text{D}$, $\Delta H = +500 \text{ kJ}$, and $K_{\text{p}} = 1 \times 10^{-10}$. Which of the following statements is incorrect?

- A) The reaction is endothermic.
- B) $\Delta G^\circ > 0$
- C) $\Delta G^\circ = 0$
- D) The equilibrium favors the reactants.
- E) $\Delta G = 0$

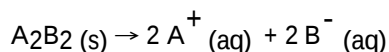
Answer: C

15) What is the pKa if the Ka is 0.00000860 ?

- A) 5.1
- B) -5.1
- C) 4.8
- D) 10
- E) 5.4

Answer: A

16) What is the molar solubility for a slightly soluble salt whose $K_{\text{sp}} = 2.0 \times 10^{-16}$?



- A) 2.3×10^{-6}
- B) 3.5×10^{-9}
- C) 1.7×10^{-4}
- D) 5.9×10^{-5}
- E) 1.2×10^{-4}

Answer: D

17) Above what temperature, in $^\circ\text{C}$, will the following reaction become spontaneous? Assume free energy, enthalpy, and entropy are not temperature dependent.

		$\text{N}_2\text{O}_4(\text{g})$	$\rightarrow$	$2 \text{NO}_2(\text{g})$	$\Delta G^\circ = 4.801$
ΔH_f°	kJ/mol	9.16		33.18	
S°	J/mol	304.2		240.0	

- A) 57.2
- B) 0.32
- C) 4.80
- D) 325.4
- E) 52.4

Answer: E

18) Which of the following reactions leads to an increase in entropy of the system?

- A) $\text{CaO (s)} + \text{CO}_2 \text{ (g)} \rightarrow \text{CaCO}_3 \text{ (s)}$
- B) $4 \text{ Fe (s)} + 3 \text{ O}_2 \text{ (g)} \rightarrow 2 \text{ Fe}_2\text{O}_3 \text{ (s)}$
- C) $\text{NH}_4\text{Cl (s)} \rightarrow \text{HCl (g)} + \text{NH}_3 \text{ (g)}$
- D) $2 \text{ HI (g)} + \text{Cl}_2 \text{ (g)} \rightarrow 2 \text{ HCl (g)} + \text{I}_2 \text{ (s)}$
- E) $\text{CH}_4 \text{ (g)} + 2 \text{ O}_2 \text{ (g)} \rightarrow \text{CO}_2 \text{ (g)} + 2 \text{ H}_2\text{O (l)}$

Answer: C

19) What is the pH of a solution containing 0.00044 moles H^+ per liter?

- A) 3.7
- B) -3.4
- C) 3.4
- D) 0.00044
- E) 1.0

Answer: C

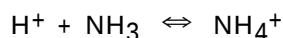
20) If 100. mL of 0.025 M NaCl is mixed with 150. mL of 0.0015 M $\text{Pb}(\text{NO}_3)_2$, will a precipitate form?

($K_{\text{sp}} \text{ PbCl}_2 = 1.6 \times 10^{-5}$)

- A) No, because $Q_{\text{ip}} > K_{\text{sp}}$.
- B) Yes, because $Q_{\text{ip}} > K_{\text{sp}}$.
- C) Yes, because $Q_{\text{ip}} < K_{\text{sp}}$.
- D) No, because $Q_{\text{ip}} < K_{\text{sp}}$.
- E) No, because $Q_{\text{ip}} = K_{\text{sp}}$.

Answer: D

21) Identify the Lewis Base in the following equation.



- A) H_2O
- B) H^+
- C) NH_3
- D) NH_4^+
- E) not an acid-base reaction

Answer: C

22) The pH of acid rain may be as low as 2.80. What is the $[\text{H}_3\text{O}^+]$ in such acidic rain?

- A) 1.6
- B) 630
- C) 6.3×10^{-12}
- D) 1.6×10^{-3}
- E) 9.7×10^{-2}

Answer: D

23) Which of the following salts is most soluble in pure water?

- A) ZnS, $K_{\text{sp}} = 1.6 \times 10^{-24}$
- B) CuS, $K_{\text{sp}} = 8.7 \times 10^{-36}$
- C) PbI_2 , $K_{\text{sp}} = 7.1 \times 10^{-9}$
- D) HgS, $K_{\text{sp}} = 2.0 \times 10^{-53}$
- E) AgI, $K_{\text{sp}} = 8.5 \times 10^{-17}$

Answer: C

24) The conjugate acid of HPO_4^{2-} is

- A) H_2PO_4^-
- B) PO_4^{3-}
- C) H_3PO_4
- D) $\text{H}_2\text{PO}_4^{2-}$
- E) none of these

Answer: A

25) What conditions would apply to a reaction that is not spontaneous at low temperature but becomes spontaneous at higher temperatures?

- A) decrease in enthalpy and increase in entropy
- B) increase in enthalpy and decrease in entropy
- C) decrease in enthalpy and decrease in entropy
- D) increase in enthalpy and increase in entropy
- E) No conditions allow for such a result.

Answer: D

26) A saturated solution of $\text{Mg}(\text{OH})_2$ has a pH of 11.03. Determine the K_{sp} for $\text{Mg}(\text{OH})_2$.

- A) 4.96×10^{-12}
- B) 6.1×10^{-10}
- C) 1.15×10^{-8}
- D) 6.1×10^{-8}
- E) 6.2×10^{-12}

Answer: B

27) Calculate the molar concentration of free Ag^+ in an aqueous solution that is 0.20 M AgNO_3 and also 2.5 M $\text{Na}_2\text{S}_2\text{O}_3$. ($K_f[\text{Ag}(\text{S}_2\text{O}_3)_2]^{3-} = 1.7 \times 10^{13}$)

- A) 1.5×10^{13}
- B) 2.7×10^{-15}
- C) 2.5×10^{-5}
- D) 1.9×10^{-15}
- E) 4.7×10^{-15}

Answer: B

28) Calculate the pH after 10.0 mL of 0.40 M NaOH is added to 20.0 mL of 0.50 M HCl .

- A) 0.30
- B) 7.00
- C) 13.30
- D) 0.70
- E) 13.70

Answer: D

29) Which of the following is the strongest acid?

- A) HCl
- B) H_2S
- C) PH_3
- D) SiH_4
- E) CH_4

Answer: A

30) What is the correct K_{sp} expression for $\text{Ca}_3(\text{PO}_4)_2$?

- A) $[\text{Ca}^{2+}][\text{PO}_4^{3-}]$
- B) $[\text{Ca}^{2+}]^3[\text{PO}]^4$
- C) $[\text{Ca}^{3+}][\text{PO}_4^{2-}]$
- D) $[\text{Ca}^{2+}]^3[\text{P}]^2[\text{O}_4]^2$
- E) $[\text{Ca}^{2+}]^3[\text{PO}_4^{3-}]^2$

Answer: E

31) For which of the following processes would the entropy change be positive?

- A) $\text{I}_2(\text{s}) \rightarrow \text{I}_2(\text{aq})$
- B) $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{s})$
- C) $\text{Hg}(\text{l}) (45^\circ\text{C}) \rightarrow \text{Hg}(\text{l}) (25^\circ\text{C})$
- D) $\text{He}(\text{g}) (1 \text{ atm}) \rightarrow \text{He}(\text{g}) (10 \text{ atm})$
- E) $\text{Ag}^+(\text{aq}) + \text{Br}^-(\text{aq}) \rightarrow \text{AgBr}(\text{s})$

Answer: A

32) Calculate the pOH of a 3.5×10^{-2} M NaOH solution.

A) 1.46

B) 12.54

C) 0.46

D) 2.46

E) 11.46

Answer: A

33) For a certain reaction, the standard free energy change is -80.0 kJ at 300 K and -40.0 kJ at 600 K. For this reaction

A) ΔH is positive, and ΔS is positive.

B) ΔH is positive, and ΔS is negative.

C) ΔH is negative, and ΔS is negative.

D) ΔH is negative, and ΔS is positive.

E) impossible to tell

Answer: C

34) In the titration of 20.0 mL of 0.200 M HOBr with 0.100 M NaOH, what is the pH after 20.0 mL of the NaOH solution is added? (K_a HOBr = 2.5×10^{-9})

A) 8.60

B) 4.65

C) 5.74

D) 7.00

E) none of these

Answer: A

35) The solubility product for $Zn(OH)_2$ is 3.0×10^{-16} . What is the molar concentration of Zn^{2+} ions in a solution of pH = 9.00 ?

A) 3.0×10^{-6}

B) 6.8×10^{-6}

C) 300

D) 4.2×10^{-6}

E) 7.5×10^{-7}

Answer: A

36) Which of the following variables are NOT needed to solve the van't Hoff equation?

A) temperature

B) enthalpy

C) universal gas constant

D) equilibrium constant

E) entropy

Answer: E

37) What is the value of K_a for an acid if $[H_3O^+] = 0.13$ M, $[A^-] = 0.820$ M, and $[HA] = 2.00$ M at equilibrium ?

A) 0.48

B) 0.54

C) 19

D) 0.053

E) 0.21

Answer: D

38) Given the following K_a values,

HC₂H₃O₂ 1.8×10^{-5}

HClO₃ 5.0×10^2

HCN 6.2×10^{-10}

HF 6.6×10^{-4}

HOCl 2.9×10^{-8}

which of the following is the weakest base?

A) ClO₃⁻

B) F⁻

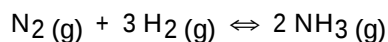
C) OCl⁻

D) CN⁻

E) C₂H₃O₂⁻

Answer: A

39) Consider the following exothermic reaction:



Which of the following changes would not increase the amount of NH_3 produced from given quantities of N_2 and H_2 ?

- A) an increase in T
- B) a decrease in V
- C) removing some NH_3 and reestablishing equilibrium
- D) an increase in P
- E) none of the above

Answer: A

40) Which one of the following processes is not spontaneous and endothermic (at 1 atm)?

- A) melting of ice at 10°C
- B) sublimation of CO_2 at 25°C
- C) $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{g})$ at 101°C
- D) dissolving the soluble salt, NH_4NO_3 , and the temperature drops
- E) condensation of water at 99°C

Answer: E

41) The metal center in a complex ion is

- A) a Lewis acid.
- B) a ligand.
- C) a Lewis base.
- D) a Bronsted-Lowry base.
- E) insoluble in the solvent.

Answer: A

42) For the phase transition from solid to liquid, $\Delta H_{\text{fusion}} = 15.1 \text{ kJ/mol}$ and $\Delta S_{\text{fusion}} = 487 \text{ J/mol K}$. At what temperature ($^\circ\text{C}$) does this phase transition take place?

- A) -273
- B) -205
- C) -242
- D) 0.0310
- E) 31.0

Answer: C

43) With which of the following bases will the reaction of acetic acid, CH_3COOH , proceed farthest toward completion.

- A) Cl^-
- B) NO_3^-
- C) CO_3^{2-}
- D) HSO_4^-
- E) F^-

Answer: C

44) Calcium sulfate is sometimes added to wine both to clarify and to precipitate dissolved lead. Given the following K_{sp} values, what $[\text{Pb}^{2+}]$ remains in wine that is saturated with CaSO_4 ?

($K_{\text{sp}} \text{CaSO}_4 = 9.1 \times 10^{-6}$, $K_{\text{sp}} \text{PbSO}_4 = 1.6 \times 10^{-8}$)

- A) 1.3×10^{-4}
- B) 1.8×10^{-2}
- C) 5.3×10^{-6}
- D) 1.5×10^{-13}
- E) 3.0×10^{-3}

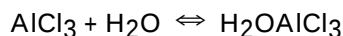
Answer: C

45) What is $[\text{H}_3\text{O}^+]$, if the pH = 10 ?

- A) 1.00×10^{-10}
- B) 4.54×10^{-5}
- C) -2.30
- D) -1.00
- E) 1.00×10^{10}

Answer: A

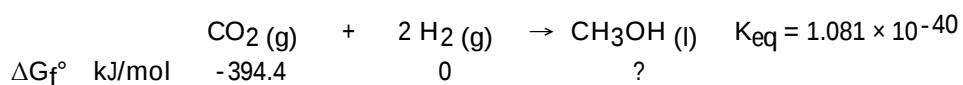
46) Identify the Lewis Acid in the following equation.



- A) H_2O
- B) H^+
- C) H_2OAlCl_3
- D) AlCl_3
- E) Cl^-

Answer: D

47) Given the following data, what is the value of ΔG_f° (in kJ) for $\text{CH}_3\text{OH}(\text{l})$ at 25°C .



- A) -166.4
- B) 622.4
- C) 92.0
- D) 228.0
- E) Not enough information is given.

Answer: A

48) A saturated solution of AgCrO_3 contains 14 mg AgCrO_3 per liter of solution. What is K_{sp} for AgCrO_3 ?

- A) 4.5×10^{-9}
- B) 2.2×10^8
- C) 1.4×10^{-3}
- D) 1.3×10^{-4}
- E) 6.7×10^{-5}

Answer: A

49) Use Trouton's rule to estimate the normal boiling point of hexane, in $^\circ\text{C}$, given that at this temperature $\Delta H_{\text{vap}} = 29.8 \text{ kJ/mol}$.

- A) 2.9
- B) 343
- C) 45
- D) 34
- E) 70

Answer: E

50) In which of the following solutions would the solubility of calcium carbonate be the smallest?

- A) pure water
- B) 0.5 M sodium chloride
- C) 0.1 M calcium chloride
- D) 0.2 M sodium carbonate
- E) 0.1 M HCl

Answer: D