DO NOT OPEN THIS EXAM UNTIL INSTRUCTED. CALCULATORS ARE NOT TO BE SHARED.

Test Form 1

Instructions: You should have with you several number two pencils, an eraser, your 3" x 5" note card, a calculator, and your University ID Card. If you have notes with you, place them in a sealed backpack and place the backpack OUT OF SIGHT or place the notes directly on the table at the front of the room.

Fill in the front page of the Scantron answer sheet with your test form number (listed above), last name, first name, middle initial, and student identification number. Leave the class section number blank.

This exam consists of 25 multiple-choice questions. Each question has four points associated with it. Select the best multiple-choice answer by filling in the corresponding circle on the rear page of the answer sheet. If you have any questions before the exam, please ask. If you have any questions during the exam, please ask the proctor. Open and start this exam when instructed. When finished, place your Scantron form in the appropriate stack. You may keep the exam packet, so please show your work and mark the answers you selected on it.

\[
K_a[\text{CH}_2\text{COOH} \text{(aq)}] = 1.80 \times 10^{-5} \\
K_a[\text{CH}_2\text{C}_2\text{COOH} \text{(aq)}] = 1.10 \times 10^{-3} \\
K_a[\text{C}_6\text{H}_5\text{COOH} \text{(aq)}] = 6.30 \times 10^{-10} \\
K_a[\text{NH}_3 \text{(aq)}] = 1.80 \times 10^{-5} \\
K_a[\text{HCOOH} \text{(aq)}] = 1.80 \times 10^{-4} \\
K_{\text{sp}}[\text{PbF}_2, \text{lead fluoride}] = 3.6 \times 10^{-8} \\
K_{\text{sp}}[\text{MgF}_2, \text{magnesium fluoride}] = 3.7 \times 10^{-9}
\]
1. The pH of 0.040 M HNO₃ (aq) is:
   (A) 0.040
   (B) 0.140
   (C) 1.40
   (D) 12.66
   (E) 13.96.

2. The [OH⁻] of 0.040 M HCl (aq) is:
   (A) 0.040 M
   (B) 0.140
   (C) 1.00 x 10⁻⁷ M
   (D) 2.51 x 10⁻³ M
   (E) 1.00 x 10⁻⁹ M.

3. The pH of 0.150 M C₆H₅COOH (aq) is:
   (A) 0.150
   (B) 0.300
   (C) 2.51
   (D) 2.74
   (E) 3.74.

4. The pH of an aqueous system is measured to be 3.46. The pH of this system is:
   (A) 0.539
   (B) 3.46
   (C) 3.47 x 10⁻⁴
   (D) 7.66
   (E) 10.54.
5. The pH of a buffer system which is 1.30 M CH₂CICOOH (aq) and 1.30 M CH₂CICOONa (aq) is:

\[
\text{CH₂CICOOH (aq) } \rightleftharpoons \text{CH₂CICOO⁻ (aq) } + \text{H⁺ (aq)}
\]

\[
\text{\(K_a = 1.40 \times 10^{-3}\)}
\]

\[
\text{\[
\frac{[\text{CH₂CICOO⁻}][\text{H⁺}]}{\text{[CH₂CICOOH]}} = \frac{(1.30)}{(1.30)}
\]
\]

\[
\text{[H⁺]} = 1.40 \times 10^{-3} \text{ M}
\]

\[
\text{pH} = -\log [\text{H⁺}] = -\log (1.40 \times 10^{-3}) = 2.85
\]

6. Which buffer system has the LOWEST pH?

(A) 0.50 M C₆H₅COOH (aq) and 0.50 M C₆H₅COONa (aq)
(B) 1.00 M C₆H₅COOH (aq) and 0.50 M C₆H₅COONa (aq)
(C) 0.50 M C₆H₅COOH (aq) and 1.00 M C₆H₅COONa (aq)

7. Consider CH₃COOH, CH₂CICOOH, and C₆H₅COOH. The strongest acid is:

(A) CH₃COOH
(B) CH₂CICOOH
(C) C₆H₅COOH

8. Consider the molecule below.

This molecule is:

(A) a strong acid
(B) a weak acid
(C) a strong base
(D) a weak base
(E) a polyprotic base
9. A student titrates 0.550 grams of KHP (potassium hydrogen phthalate; MW=204.2 g/mol) to the equivalence point with 36.60 mL of NaOH (aq). The concentration of the NaOH solution is:

(A) 3069 M
(B) 13.6 M
(C) 0.0913 M
(D) 0.100 M
(E) 0.0736 M

\[ \frac{\text{M}_\text{NaOH} \times \text{V}_\text{NaOH}}{\text{M}_\text{KHP} \times \text{V}_\text{KHP}} = \frac{0.550 \text{ g}}{204.2 \text{ g/mol}} \]

\[ (\text{M}_\text{NaOH})(0.03660 \text{ L}) = \frac{0.550 \text{ g}}{204.2 \text{ g/mol}} \]

\[ \text{M}_\text{NaOH} = 0.0736 \text{ M} \]

10. Consider the reaction of formic acid (HCOOH), and water. The conjugate base is:

(A) HCOOH
(B) NH₃
(C) HCOO⁻
(D) H⁺
(E) H₂O⁺

HCOOH (aq) + H₂O (l) \rightarrow HCOO⁻(aq) + H₃O⁺

11. The pH of 1.00 M sodium acetate, CH₃COONa (aq), is:

(A) Greater than 7.00
(B) 7.00
(C) Less than 7.00

CH₃COO⁻ is a base \((\text{pH} > 7)\)

CH₃COO⁻ + H₂O \rightarrow CH₃COOH + OH⁻

Na⁺ is a spectator ion

12. A student titrates 35.00 mL of HCl (aq) with 18.22 mL of 0.2004 M NaOH (aq) to reach the equivalence point. The concentration of HCl (aq) is:

(A) 0.3850 M
(B) 0.1043 M
(C) 0.1322 M
(D) 1.41 x 10⁻³ M
(E) 9.386 M

At the equivalence point:

\[ \text{M}_\text{NaOH} \times \text{V}_\text{NaOH} = \text{M}_\text{HCl} \times \text{V}_\text{HCl} \]

\[ (0.2004 \text{ M})(18.22 \text{ mL}) = (\text{M}_\text{HCl})(35.00 \text{ mL}) \]

\[ \text{M}_\text{HCl} = 0.1043 \text{ M} \]
13. Which of the following selections contains only acids?
(A) HNO₃, NaNO₃, HCl, NaCl
(B) NaOH, KOH, NH₃, OH⁻, Ca(OH)₂
(C) H₂SO₄, HNO₃, HCl, NH₃
(D) HNO₃, CH₃COOH, CH₃CH₂COOH

14. The solubility of MgF₂ is:
(A) 1.9 x 10⁻¹¹ M
(B) 1.9 x 10⁻⁹ M
(C) 1.9 x 10⁻⁷ M
(D) 2.1 x 10⁻⁷ M
(E) 1.4 x 10⁻⁶ M

15. A solution was made 3.0 x 10⁻³ M in [Pb²⁺] and 2.5 x 10⁻³ M in [F⁻].
(A) A precipitate will form.
(B) A precipitate will not form.

16. Consider the combustion of octane: 2 C₈H₁₈(ℓ) + 25 O₂(g) → 16 CO₂(g) + 18 H₂O(g) ΔH⁻
(A) ΔH = (+), ΔS = (+), and ΔG = (-).
(B) ΔH = (+), ΔS = (+), and ΔG = (-).
(C) ΔH = (-), ΔS = (+), and ΔG = (-).
(D) ΔH = (-), ΔS = (+), and ΔG = (-).

25 mol gas 39 mol gas

ΔS = (+) More disorder
ΔG = (-) Spontaneous
17. Which of the following statements is true?

(A) All endothermic processes which result in a system of greater disorder are spontaneous.
(B) All endothermic processes which result in a system of greater order are spontaneous.
(C) All exothermic processes which result in a system of greater disorder are spontaneous.
(D) All exothermic processes which result in a system of greater order are spontaneous.

\[ \Delta H = (-) \quad \Delta S = (-) \quad \Delta G = (-) \]

See Question 16 for an example.

18. Consider the "cold pack" reaction: \( \text{NH}_2\text{NO}_3 (s) \rightarrow \text{NH}_3\text{NO}_3 (aq) \).

(A) \( \Delta H = (-), \Delta S = (+), \) and \( \Delta G = (-) \).
(B) \( \Delta H = (-), \Delta S = (-), \) and \( \Delta G = (-) \).
(C) \( \Delta H = (+), \Delta S = (+), \) and \( \Delta G = (-) \).
(D) \( \Delta H = (+), \Delta S = (-), \) and \( \Delta G = (-) \).

19. Consider the process: \( \text{CO}_2 (s) \rightarrow \text{CO}_2 (g) \).

(A) \( \Delta S \) is negative.
(B) \( \Delta S \) is positive.

20. Which of the following processes exhibits an increase in entropy of the system?

(A) \( \text{NH}_2\text{NO}_3 (aq) \rightarrow \text{NH}_3\text{NO}_3 (s) \)
(B) \( \text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{O}(s) \)
(C) \( \text{H}_2\text{O}(s) \rightarrow \text{H}_2\text{O}(g) \)
(D) \( 2\text{NO}_2 (g) \rightarrow \text{N}_2\text{O}_4 (g) \)
(E) \( \text{CH}_3\text{CH}_2\text{OH} (g) \rightarrow \text{CH}_3\text{CH}_2\text{OH} (l) \)

21. \( \Delta H = -123 \text{ kJ} \) and \( \Delta S = -203 \text{ J/K} \) for a process. Determine \( \Delta G \) at 298 K.

(A) \( -62.5 \text{ kJ} \)
(B) +62.5 kJ.
(C) -60.371 kJ.
(D) +183 kJ.
(E) -183 kJ.
22. Given the following reactions:

\[ 2\text{SO}_2(g) + O_2(g) \rightarrow 2\text{SO}_3(g) \quad \Delta S_1 = -196 \text{ J/K} \]
\[ 2\text{S(s)} + 3\text{O}_2(g) \rightarrow 2\text{SO}_3(g) \quad \Delta S_2 = -790 \text{ J/K} \]

Calculate the change in entropy for:

\[ \text{S(s)} + \frac{1}{2} \text{O}_2(g) \rightarrow \text{SO}_2(g) \quad \Delta S_3 = ? \]

(A) \( \Delta S_3 = -790 \text{ J/K} \)
(B) \( \Delta S_3 = -199 \text{ J/K} \)
(C) \( \Delta S_3 = -986 \text{ J/K} \)
(D) \( \Delta S_3 = -986 \text{ J/K} \)
(E) \( \Delta S_3 = 297 \text{ J/K} \)

23. \( \Delta H^o = -103 \text{ kJ} \) and \( \Delta S^o = -224 \text{ J/K} \) for a process. Determine the temperature in which the system is at equilibrium?

\[ \Delta G = \Delta H - T \Delta S \]
\[ 0 = (-103 \text{ kJ}) - (T)(-0.224 \text{ kJ/K}) \]
\[ T = 455 \text{ K} \]

(A) 298 K
(B) 455 K
(C) 350 K
(D) 0 K
(E) 4 K

24. Consider the process: \( 2\text{CO}_2(g) \rightarrow 2\text{CO}(g) + \text{O}_2(g) \)

(A) \( \Delta S \) is negative
(B) \( \Delta S \) is positive

2 mol gas \( \rightarrow \) 3 mol gas

\( \Delta S = + \)

25. Because of Chemistry 123...

(A) I am staying 15 degrees cooler than my non-chemistry friends.
(B) My permanshp has improved.
(C) My batting average has increased from 283 to 460.
(D) I am motivated to invent a better tasting sports drink.
(E) I am changing my major to chemistry and my last name to Boltzmann... today!

[Any response will receive full credit, even no response.]