This sample exam contains selected questions from 3 of the sample exams located on the library’s course reserve page for Dr. Block’s Chem 1310 exam. Please attempt all of the questions before coming to the review session on Wednesday, Oct 13, 5 pm, CoC16. No copies will be handed out. Keys for all of the sample exams will be emailed Wednesday night after the review session.

O4. Which is the strongest acid?
   a. HINO$_3$, $K_a = 1.6 \times 10^{-1}$
   b. HF, $K_a = 6.6 \times 10^{-1}$
   c. HN$_3$, $K_a = 1.9 \times 10^{-5}$
   d. HCOOH, $K_a = 1.8 \times 10^{-4}$

O5. Which is the weakest base?
   a. IO$_3^-$
   b. F$^-$
   c. N$_3^-$
   d. HCOO$^-$

O6. A binary compound of mercury and oxygen was heated until it decomposed completely yielding 401.2 mg of mercury and 25.5 mL of dry oxygen gas (measured at 735 torr and 27$^\circ$ C). What was the formula of the original binary compound of mercury?
   a. Hg$_2$O
   b. HgO
   c. HgO$_2$
   d. Hg$_2$O$_3$
Questions 9 – 11 deal with solutions of chlorous acid and/or its salts. \(K_a = 1.1 \times 10^{-2}\) for HClO₂

9. What is the pH of 2.0 M HClO₂?
   - a. 1.96
   - b. 0.83
   - c. 3.90
   - d. 5.83

10. What is the pH of 2.0 M sodium chlorite, NaClO₂?
    - a. 13.17
    - b. 5.87
    - c. 8.13
    - d. 11.22

11. What is the pH of a solution that is both 2.0 M HClO₂ and 2.0 M NaClO₂?
    - a. 10.12
    - b. 7.00
    - c. 3.59
    - d. 1.96

13. A 2.162 g sample of a pure metal, M, was treated with an excel of hydrochloric acid to form the M(II) chloride and 0.997 L of hydrogen gas at 20.0°C and 0.925 atm. What is the most likely identity of M?
   - a. iron
   - b. silicon
   - c. antimony
   - d. rubidium
O15. The pH of a $10^{-8} \text{ M}$ HCl solution is not 8.00. What best explains this observation?
   a. HCl is a weak acid so it’s not completely dissociated in aqueous solution.
   b. Ion pairs tend to form in concentrated solutions.
   c. The contribution of the autoionization of water to $[\text{H}_3\text{O}^+]$ is comparable to the contribution of the acid.
   d. Dilute solutions tend to be less ideal than concentrated solutions.

O17. Which statement about gases is true?
   a. Particles of ideal gas repel each other slightly; particles of real gases attract each other when confined to small containers at high pressure and high temperature.
   b. Particles of ideal gas have small volumes; the molecular volume of a real gas depends solely on the number of atoms per molecule.
   c. All real gases have molar volumes less than 22.414 L at STP.
   d. It would be impossible to liquefy an ideal gas.

E1. Pure acetone has a vapor pressure of 0.3720 atm at 30 °C. If 0.12 moles of a non-dissociating solid is dissolved in 0.86 moles of acetone, the resulting vapor pressure will be:
   a. 0.340 atm
   b. 0.026 atm
   c. 0.326 atm
   d. 0.400 atm
   e. none of these
E2. The following reaction takes place at 454 K

\[ 3 \text{Al}_2\text{Cl}_6(g) \leftrightarrow 2 \text{Al}_3\text{Cl}_9(g) \]

The correct equilibrium expression is:

a. \( \frac{3P_{\text{Al}_2\text{Cl}_6}}{2P_{\text{Al}_3\text{Cl}_9}} \)

b. \( \frac{P_{\text{Al}_3\text{Cl}_9}^2}{P_{\text{Al}_2\text{Cl}_6}^3} \)

c. \( \frac{2P_{\text{Al}_3\text{Cl}_9}}{3P_{\text{Al}_2\text{Cl}_6}} \)

d. \( \frac{P_{\text{Al}_2\text{Cl}_6}^3}{P_{\text{Al}_3\text{Cl}_9}^2} \)

b. none of these

E4. The reaction \( 2 \text{NO}(g) + \text{Br}_2(g) \leftrightarrow 2 \text{NOBr}(g) \) has an equilibrium constant of 116.6 at 25 °C. Under the following conditions, \( Q = \) ________ and the reaction will proceed to the ________.

\[ P_{\text{NO}} = 0.260 \text{ atm} \quad P_{\text{Br}_2} = 0.760 \text{ atm} \quad P_{\text{NOBr}} = 1.86 \text{ atm} \]

a. 67.3, left
b. 72.4, left
c. 72.4, right
d. 67.3, right
e. none of these

E6. Which of the following constitutes a Brønsted-Lowry conjugate acid-base pair?

a. \( \text{H}_2\text{SO}_4; \text{SO}_4^{2-} \)

b. \( \text{H}_3\text{O}^+; \text{OH}^- \)

c. \( \text{NH}_4^+; \text{NH}_3 \)

d. \( \text{H}_2\text{CO}_3; \text{CO}_3^{2-} \)

e. none of these

E7. If 400 mL of 0.06 molar aqueous NaOH is diluted to 1 L, the resulting pH is

a. 1.6
b. 1.2
c. 12.4
d. 13.7
e. none of these
E8. This question will be worked in the review session – phase diagram question.

E10. In a gas-phase reaction, the yield of products is decreased by increasing the pressure and reducing the temperature. This is an indication that the reaction is ________ and as product is formed there is a net ________ in the number of gas molecules.
   a. Exothermic, increase
   b. Exothermic, decrease
   c. Endothermic, increase
   d. Endothermic, decrease
   e. There is insufficient data

E11. The $K_a$ of hydrosulfuric acid is $9.1 \times 10^{-8}$. A water solution of 0.15 molar hydrosulfuric acid will have a pH of
   a. 7.04
   b. 3.93
   c. 3.52
   d. 6.24
   e. none of these

C1. What is the value of $v$ (maximum number of particles per formula unit) for aluminum nitrate?
   a. 2
   b. 3
   c. 4
   d. 5
C3. An impure sample of sodium chlorate is decomposed, producing sodium chloride and oxygen gas. Decomposition of a sample weighing 265 mg produced 35.00 mL of dry oxygen (measured at STP). What was the percentage of sodium chlorate in the original impure sample?
   a. 41.8 %
   b. 13.2 %
   c. 22.4 %
   d. 68.3 %

C4. Which gas should behave most ideally when the gases are all at 273 K and 50 atm pressure?
   a. Argon
   b. Ozone, O₃
   c. Methane, CH₄
   d. Hydrazine, N₂N₄

C7. A 9.20 M solution of perchloric acid has a density of 1.54 g/mL. What is the molality of this solution?
   a. 9.20 m
   b. 15.0 m
   c. 5.97 m
   d. 10.7 m

C8. What is the expected freezing point of a solution containing 50.0 g of sodium chloride in 1.00 kg of water? Assume that I (actual number of particles per formula unit) is 1.7; kᵣ = -1.86 K kg/mol for water.
   a. -0.16 °C
   b. -1.6 °C
   c. -0.093 °C
   d. -2.7 °C
C13. Which stresses would cause an increase in the equilibrium partial pressure of sulfur trioxide if the reaction being considered is: \( \text{SO}_2(g) + 0.5 \text{O}_2(g) = \text{SO}_3(g) + \text{heat} \)

i. lowering the temperature of the reaction mixture
ii. adding \( \text{O}_2(g) \) at constant temperature and volume
iii. increasing the volume of the mixture at constant temperature and pressure
iv. adding \( \text{N}_2(g) \) at constant volume and temperature

a. i and ii only
b. ii and iii only
c. ii and iv only
d. i and iv only

C19. You need to prepare a buffer solution that will maintain a fairly constant pH of 5.5. Which is the best acid/base conjugate pair to use in making your buffer?

a. Ammonium chloride / ammonia (\( K_a = 5.6 \times 10^{-10} \) for \( \text{NH}_4^+ \))
b. Chlorous acid / potassium chlorite (\( K_a = 1.1 \times 10^{-2} \) for \( \text{HClO}_2 \))
c. Propionic acid / sodium propionate (\( K_a = 1.3 \times 10^{-5} \) for \( \text{C}_2\text{H}_5\text{COOH} \))
d. Hypochlorous acid / potassium hypochlorite (\( K_a = 3.0 \times 10^{-8} \) for \( \text{HClO}_2 \))

C20. What would be the pH of a solution prepared by mixing 40.0 mL of 0.1000 M acetic acid with 10.00 mL of 0.1000 M NaOH? (\( K_a = 1.8 \times 10^{-5} \) for \( \text{CH}_3\text{COOH} \))

a. 2.87
b. 4.27
c. 4.74
d. 6.07