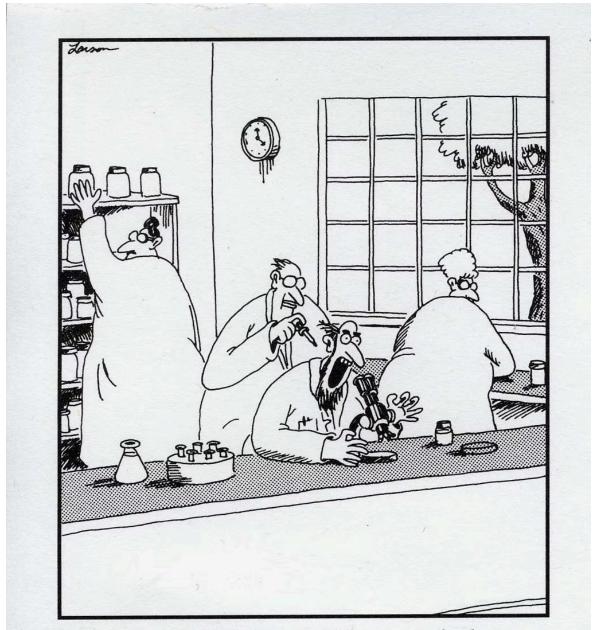Exam 2 Review R and R Worksheet
7/31/24

Professor Glickman, the lab practical joker,
deftly places a single drop of hydrochloric acid
on the back of Professor Bingham's neck.

Acids and Bases 🍋

1) Chloroacetic acid ($ClCH_2CO_2H$) has K_a = 1.41 × 10^{-3}. What is the value of K_b for the chloroacetate ion ($ClCH_2CO_2^-$)?

2) For each of the following reactions, predict whether the equilibrium lies predominantly to the left or to the right. Explain your predictions briefly.

(a) $CH_3CO_2H(aq) + Br^+(aq) \Leftrightarrow CH_3CO_2^-(aq) + HBr(aq)$

(b) $H_3PO_4(aq) + F^+(aq) \Leftrightarrow H_2PO_4^-(aq) + HF(aq)$

3) Sulfurous acid, H_2SO_3, is a weak acid capable of providing two H^+ ions.

(a) What is the pH of a 0.45 M solution of H_2SO_3?

(b) What is the equilibrium concentration of the sulfite ion, SO_3^{2-}, in the 0.45 M solution of H_2SO_3?

4) What is the pH of 1.0 L of 0.20 M acetic acid to which 16.4 g of sodium acetate, $NaCH_3CO_2$, is added?

5) What is the pH of the buffer solution that contains 2.2 g of NH_4Cl in 250 mL of 0.12 M NH_3? Is the final pH lower or higher than the pH of the 0.12 M ammonia solution?

6) What must the ratio of acetic acid to acetate ion be to have a buffer with a pH value of 4.50?

7) Which of the following combinations would be the best to buffer the pH of a solution at approximately 9?

(a) HCl and NaCl
(b) NH_3 and NH_4Cl
(c) CH_3CO_2H and $NaCH_3CO_2$

8) You titrate 25.0 mL of 0.10 M NH_3 with 0.10 M HCl.
(a) What is the pH of the NH_3 solution before the titration begins?

(b) What is the pH at the equivalence point?

(c) What is the pH at the halfway point of the titration?

Solubility 🧂

9) When 1.55 g of solid thallium(I) bromide is added to 1.00 L of water, the salt dissolves to a small extent.

$TlBr(s) \Leftrightarrow Tl^+(aq) + Br^-(aq)$

The thallium(I) and bromide ions in equilibrium with TlBr each have a concentration of 1.9×10^{-3} M. What is the value of K_{sp} for TlBr?

10) Calculate the molar solubility of silver thiocyanate, AgSCN, in pure water and in water containing 0.010 M NaSCN. 17.63

11) You have a solution that has a lead(II) ion concentration of 0.0012 M. If enough soluble chloride-containing salt is added so that the Cl^- concentration is 0.010 M, will $PbCl_2$ precipitate?

12) If the concentration of Zn^{2+} in 10.0 mL of water is 1.63×10^{-4} M, will zinc hydroxide, $Zn(OH)_2$, precipitate when 4.0 mg of NaOH is added?

Thermodynamics 🌡️

13) Which substance in each pair has the higher entropy?

(a) Dry ice (solid CO_2) at −78 °C or $CO_2(g)$ at 0 °C.
(b) Liquid water at 25 °C or liquid water at 50 °C.
(d) One mole of $N_2(g)$ at 1 bar pressure or one mole of $N_2(g)$ at 10 bar pressure (both at 298 K).

14) Calculate the standard entropy change for the following reactions at 25°C.

(a) 2 Al(s) + 3 $Cl_2(g)$ → 2 $AlCl_3(s)$

(b) 2 $CH_3OH(l)$ + 3 $O_2(g)$ → 2 $CO_2(g)$ + 4 $H_2O(g)$

15) Using values of $\Delta_f H°$ and $S°$, calculate $\Delta_r G°$ for each of the following reactions at 25°C.

(a) 2 Pb(s) + $O_2(g)$ → 2 PbO(s)

(b) $NH_3(g) + HNO_3(aq) \rightarrow NH_4NO_3(aq)$

Which of these reactions is (are) predicted to be product-favored at equilibrium? Are the reactions enthalpy or entropy-driven?

16) Determine whether the reactions listed below are entropy-favored or disfavored under standard conditions. Predict how an increase in temperature will affect the value of $\Delta_r G°$.

(a) $N_2(g) + 2\ O_2(g) \rightarrow 2\ NO_2(g)$

(b) $2\ C(s) + O_2(g) \rightarrow 2\ CO(g)$

17) Calculate $\Delta_r G°$ at 25°C for the formation of 1.00 mol of $C_2H_6(g)$ from $C_2H_4(g)$ and $H_2(g)$. Use this value to calculate Kp for the equilibrium.

$C_2H_4(g) + H_2(g) \Leftrightarrow C_2H_6(g)$

Comment on the sign of $\Delta_r G°$ and the magnitude of K_p.

Electrochemistry 🔋

18) Balance the following redox equation in acidic conditions:

$Sn(s) + H^+(aq) \rightarrow Sn^{2+}(aq) + H_2(g)$

19) Balance the following redox equation in basic conditions:

$CrO_4^{2-}(aq) + SO_3^{2-}(aq) \rightarrow Cr(OH)_3(s) + SO_4^{2-}(aq)$

20) A voltaic cell is constructed using the reaction of chromium metal and iron(II) ions.

$2\ Cr(s) + 3\ Fe^{2+}(aq) \rightarrow 2\ Cr^{3+}(aq) + 3\ Fe(s)$.

Complete the following sentences: Electrons in the external circuit flow from the

_____ electrode to the _____ electrode. Negative ions move in the salt

bridge from the _____ half-cell to the _____ half-cell. The half-reaction

at the anode is _____, and that at the cathode is _____.

21) Balance each of the following unbalanced equations; then calculate the standard potential, $E°$cell, and decide whether each is product-favored at equilibrium as written. (All reactions are carried out in acid solution.)

(a) $Sn^{2+}(aq) + Ag(s) \rightarrow Sn(s) + Ag^+(aq)$

(b) $Al(s) + Sn^{4+}(aq) \rightarrow Sn^{2+}(aq) + Al^{3+}(aq)$

22) Calculate $\Delta_r G°$ and the equilibrium constant for the following reactions.

(a) $2 Fe^{3+}(aq) + 2 I^-(aq) \Leftrightarrow 2 Fe^{2+}(aq) + I_2(aq)$

(b) $I_2(aq) + 2 Br^-(aq) \Leftrightarrow 2 I^- (aq) + Br_2(l)$

23) The standard potential, $E°$cell, for the reaction of $Zn(s)$ and $Cl_2(g)$ is +2.12 V. What is the standard free energy change, $\Delta_r G°$, for the reaction?