Multiple Choice (5 points each, Put answers in CAPS in the left margin.)

R = 8.314 J/mol•K = 0.0821 L•atm/mol•K

1. The equilibrium expression for the reaction: \( \text{Ni(CO)}_4(\ell) \rightleftharpoons \text{Ni(s)} + 4 \text{CO(g)} \) is:

   a) \( K_{\text{eq}} = \frac{[\text{CO}]}{[\text{Ni(CO)}_4]} \)
   b) \( K_{\text{eq}} = \frac{1}{[\text{Ni(CO)}_4]} \)
   c) \( K_{\text{eq}} = \frac{[\text{Ni}][\text{CO}]}{[\text{Ni(CO)}_4]} \)
   d) \( K_{\text{eq}} = [\text{CO}]^4 \)
   e) \( K_{\text{eq}} = \frac{[\text{Ni}][\text{CO}]}{[\text{Ni(CO)}_4]} \)

2. For the equilibrium \( \text{H}_2(\ell) + \text{I}_2(\ell) \rightleftharpoons 2 \text{HI}(\ell) \) which of the following would result in a shift of the equilibrium to the right?

   a) Increasing pressure
   b) Adding a catalyst
   c) Adding HI
   d) Decreasing pressure
   e) Adding NaOH

3. At equilibrium, which is/are true?

   a) All chemical processes have stopped.
   b) The rate of the forward reaction equals that of the reverse.
   c) The rate constant for the forward reaction equals that of the reverse.
   d) The sum of the concentrations of the reactants equals that of the products.
   e) None of the above.

4. The reaction \( \text{CO} + 2 \text{H}_2 \rightleftharpoons \text{CH}_3\text{OH} \) (all gases) has an equilibrium constant equal to what value, if at equilibrium in a 2.00 L vessel, there are 0.302 atm \( \text{H}_2 \), 0.170 atm \( \text{CO} \), and 0.0406 atm \( \text{CH}_3\text{OH} \) present.

   a) 0.0955    b) 1.58    c) 2.61    d) 10.5    e) 26.2

5. A Bronsted-Lowery acid is:

   a) a proton acceptor.
   b) an electron pair acceptor.
   c) a proton donor.
   d) a substance that ionizes to produce protons.
   e) an electron pair donor.

6. Which of the following is a weak base?

   a) \( \text{KOH} \)
   b) \( \text{Sr(OH)}_2 \)
   c) \( \text{NH}_2\text{OH} \)
   d) \( \text{NaNH}_2 \)
   e) \( \text{Mg(OH)}_2 \)

7. In which of the following would \( \text{HCl} \) be the strongest acid?

   a) \( \text{pyridine(ℓ)} \)
   b) \( \text{HOAc(ℓ)} \)
   c) \( \text{H}_2\text{O(ℓ)} \)
   d) \( \text{NH}_3(ℓ) \)
   e) 1.0 M \( \text{NaOH(aq)} \)

8. What is the \([\text{H}^+]\) of a \( \text{HCl} \) solution that has a \( \text{pH} = 3.21 \)?

   a) \( 6.2 \times 10^{-4} \ M \)
   b) \( 4.0 \times 10^{-2} \ M \)
   c) 3.2 \( M \)
   d) 25 \( M \)
   e) 1600 \( M \)
Discussion Questions (You must show your work to receive credit):

1. Define the following: (20 points)
   - Lewis acid –
   - amphoteric –
   - homogeneous equilibrium –
   - reaction order –

2. At 373 K, \( K_P = 0.416 \) for the equilibrium \( 2 \text{NOBr} \rightleftharpoons 2 \text{NO} + \text{Br}_2 \) (all gases). If the pressures of NOBr and NO are equal, what is the equilibrium pressure of \( \text{Br}_2 \)? (6 points)

3. Consider an equilibrium whose forward reaction is exothermic. Which way will the equilibrium shift if the reaction is heated? Provide a physical explanation for your prediction. (6 points)

4. Explain why \( \text{HNO}_3 \) is a stronger acid than \( \text{HNO}_2 \). (6 points)
5. What is the pH of (12 points)
   a) 0.32 \( M \) HNO\(_2\) \( (K_a = 4.5 \times 10^{-4}) \)

   b) 0.121 \( M \) H\(_2\)S \( (K_{b1}(HS^-) = 5.56 \times 10^{-8}) \)
6. Consider the hypothetical reaction where \( A \) converts to a product \( (A \rightarrow B) \). Given the following data, determine the rate law for the reaction and the rate constant. What is the half life of this reaction? (You must use a half-life equation to answer this part.) (15 points)

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