**Acid Base Equilibrium**

**Multiple Choice** *Identify the choice that best completes the statement or answers the question.*

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| Nitrogen fixation occurs slowly in the atmosphere. The equation for this reaction is  N2(g) + O2(g) + 180.4 kJ  2 NO(g) Kc = 4.0 x 10-31 at 25.0°C |

\_\_\_\_ 1. The equilibrium expression for this reaction is

|  |  |  |  |
| --- | --- | --- | --- |
| a. |  | c. |  |
| b. |  | d. |  |

\_\_\_\_ 2. Equilibrium is achieved when the

|  |  |
| --- | --- |
| a. | total pressure does not change. |
| b. | rate of the forward reaction equals the rate of the reverse reaction. |
| c. | rate of the forward reaction is twice that of the rate of the reverse reaction. |
| d. | total energy changes |

\_\_\_\_ 3. At equilibrium, if the [O2(g)] = [N2(g)], then

|  |  |
| --- | --- |
| a. | [NO(g)] = [N2(g)] |
| b. | [NO(g)] > [N2(g) |
| c. | [NO(g] = 2 [N2(g)] |
| d. | [NO(g) < [N2(g)] |

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| Large quantities of ammonia are produced by the Haber-Bosch method. The essential reaction in this process involves the equilibrium  N2(g) + 3 H2(g)  2 NH3(g) + 92.2 kJ |

\_\_\_\_ 4. A catalyst is utilized in the Haber-Bosch process because the

|  |  |
| --- | --- |
| a. | reaction is exothermic. |
| b. | enthalpy of formation of ammonia is high. |
| c. | mole ratio of the reactants is 1:3. |
| d. | reaction is slow. |

\_\_\_\_ 5. The conditions that theoretically favour the formation of ammonia in the Haber-Bosch process are

|  |  |
| --- | --- |
| a. | high pressure and high temperature. |
| b. | high pressure and low temperature. |
| c. | low pressure and high temperature. |
| d. | low pressure and low temperature. |

\_\_\_\_ 6. In all chemical systems at equilibrium,

|  |  |
| --- | --- |
| a. | macroscopic properties are changing |
| b. | all the reactants are converted to products |
| c. | the amount of reactant equals the amount of products |
| d. | the forward reaction rate equals the reverse reaction rate |

\_\_\_\_ 7. For the steam-hydrocarbon reforming process, the equilibrium law expression is:



The reaction described by this equilibrium is

|  |  |
| --- | --- |
| a. | CH4(g) + 2 H2O(g)  CO2(g) + 4 H2(g) |
| b. | CO2(g) + 4 H2(g)  CH4(g) + 2 H2O(g) |
| c. | CH4(g) + H2O(g)  CO2(g) + H2(g) |
| d. | CO2(g) + H2(g)  CH4(g) + H2O(g) |

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| Tooth decay results from the dissolving of tooth enamel, Ca5(PO4)3OH(s). This decay is represented by the equilibrium equation.  Ca5(PO4)3OH(s)  5 Ca2+(aq) + 3 PO43−(aq) + OH−(aq) |

\_\_\_\_ 8. When sugar ferments on teeth, the pH level inside the mouth decreases. Tooth enamel

|  |  |
| --- | --- |
| a. | is formed as the concentration of the phosphate ion decreases and the equilibrium shifts to the left. |
| b. | is formed as the concentration of the hydroxide ion decreases and the equilibrium shifts to the left. |
| c. | dissolves as the concentration of the hydroxide ion decreases and the equilibrium shifts to the right. |
| d. | dissolves as the concentration of calcium ion decreases and the equilibrium shifts to the right. |

\_\_\_\_ 9. If the equilibrium constant, Kc, for the dissolving of tooth enamel has a value of 2.07 x 10-30, the

Kc value for the reverse reaction is

|  |  |
| --- | --- |
| a. | 4.83 x 1029 |
| b. | 4.83 x 1015 |
| c. | 2.07 x 10-16 |
| d. | -2.07 x 10-30 |

\_\_\_\_ 10. The equilibrium H2O(l) + HBb(aq)  H3O+(aq) + Bb-(aq) exists when bromothymol blue indicator is

added to water. The correct statement is

|  |  |
| --- | --- |
| a. | When KOH(aq) is added, the [HBb(aq)] increases and the solution turns yellow. |
| b. | When HCl(aq) ia added, the [H3O+(aq)] increases and the solution turns yellow. |
| c. | When HCl(aq) is added, the equilibrium shifts toward the reactants and the solution turns blue. |
| d. | When KOH(aq) is added, the equilibrium shifts toward the reactants and the solution turns yellow. |

*Use the following information to answer the next question.*

|  |
| --- |
| Antibiotics formed by different species of the genus of bacteria Penicillium are among the most widely prescribed drugs in the world today. One of these antibiotics is penicillin G (benzylpenicillinic acid), which is represented as HPn(s). This acid is only slightly soluble in water. The saturated aqueous solution is represented by the equilibrium  H2O(l) + HPn(s)  H3O+(aq) + Pn−(aq) |

\_\_\_\_ 11. This system is at equilibrium when the rate of formation of Pn-(aq) in the forward reaction is

|  |  |
| --- | --- |
| a. | favoured over the rate of the formation of HPn(s) in the reverse reaction. |
| b. | slower than the rate of the formation of HPn(s) in the reverse reaction. |
| c. | faster than the rate of the formation of HPn(s) in the reverse reaction. |
| d. | equal to the rate of the formation of HPn(s) in the reverse reaction. |

*Use the following information to answer the next question.*

|  |
| --- |
| The equilibrium law expression for an industrial method for producing ethanol is    Under certain conditions, the Kc = 300. At equilibrium, a 5 000 L reaction vessel contains 115 mol of C2H4(g) and 110 mol of H2O(g). |

\_\_\_\_ 12. Under these conditions, the equilibrium concentration of C2H5OH(g) is

|  |  |
| --- | --- |
| a. | 1.60 x 10-6 mol/L |
| b. | 0.152 mol/L |
| c. | 75.0 mol/L |
| d. | 5.92 x 105 mol/L |

*Use the following information to answer the next question.*

|  |
| --- |
| **Equilibrium Reactions at 25°C**  **I**  CO2(g) + H2(g)  CO(g) + H2O(g) Kc = 0.137  **II**  CO(g) + H2O(g)  CO2(g) + H2(g) Kc = unknown |

\_\_\_\_ 13. If hydrogen gas is added to reaction I at equilibrium, then the concentration of the carbon dioxide and the value of the Kc will

|  |  |
| --- | --- |
| a. | decrease and stay the same, respectively |
| b. | increase and stay the same, respectively |
| c. | increase and decrease, respectively |
| d. | decrease and increase, respectively |

*Use the following information to answer the next question.*

|  |
| --- |
| The decomposition of hydrogen iodide can be represented by the equilibrium equation  2 HI(g) + 53.0 kJ  H2(g) + I2(g)  A technician placed 1.00 mol of HI(g) in a 1.00 L container. The container and its contents were then heated to 425°C and allowed to reach equilibrium. |

\_\_\_\_ 14. In the reaction represented above, equilibrium is reached when the

|  |  |
| --- | --- |
| a. | HI(g) is the only species remaining in the system |
| b. | system shifts until enough energy is produced |
| c. | rate of forward reaction is equal to the rate of the reverse reaction |
| d. | amount of HI(g) is equal to the amount of H2(g) and the amount of I2(g) |

*Use the following information to answer the next question.*

|  |
| --- |
| The reaction of ammonia in water is represented by the equilibrium equation below.  NH3(aq) + H2O(l)  NH4+(aq) + OH−(aq) |

\_\_\_\_ 15. The addition of NaOH(aq) to the equilibrium above would cause the

|  |  |
| --- | --- |
| a. | equilibrium constant to decrease |
| b. | equilibrium constant to increase |
| c. | concentration of NH3(aq) to decrease |
| d. | concentration of NH4+(aq) to decrease |

*Use the following information to answer the next question.*

|  |
| --- |
| Blood pH is influenced by the concentration of buffers and gas solutes, such as carbon dioxide, which is formed during cellular respiration. In red blood cells, the enzyme carbonic anhydrase catalyzes the equilibrium  CO2(g) + H2O(l)  HCO3−(aq) + H+(aq) |

\_\_\_\_ 16. In this equilibrium, carbonic anhydrase

|  |  |
| --- | --- |
| a. | increases the concentration of HCO3−(aq) formed at equilibrium |
| b. | decreases the concentration of HCO3−(aq) formed at equilibrium |
| c. | decrease the concentration of CO2(g) at equilibrium |
| d. | increases the speed at which equilibrium is reached |

*Use the following equilibrium information to answer the next question.*

|  |
| --- |
| For the equilibrium PCl5(g)  PCl3(g) + Cl2(g)  the equilibrium constant at two temperatures is given below.  **Temperature Kc**  227°C 2.24  486°C 33.3 |

\_\_\_\_ 17. According to this information, as the temperature of the system increases, the equilibrium shifts

|  |  |
| --- | --- |
| a. | left and the reaction is exothermic |
| b. | left and the reaction is endothermic |
| c. | right and the reaction is exothermic |
| d. | right and the reaction is endothermic |

*Use the following information to answer the next question.*

|  |
| --- |
| A bleach solution can be made by dissolving chlorine gas in a sodium hydroxide solution, as shown by the equation  Cl2(g) + 2 OH−(aq)  ClO−(aq) + Cl−(aq) + H2O(l) |

\_\_\_\_ 18. Mixing a bleach solution with an acid solution can be dangerous because it can cause

|  |  |
| --- | --- |
| a. | an increase in the pH of the bleach solution |
| b. | a shift in the equilibrium to the products |
| c. | an increase in Cl2(g) concentration in the bleach solution |
| d. | an increase in Cl−(aq) concentration in the bleach solution |

\_\_\_\_ 19. In this reaction, the substances that act as Bronsted-Lowry acids are

|  |  |
| --- | --- |
| a. | OCl−(aq) and H2O(l) |
| b. | OCl−(aq) and HOCl(aq) |
| c. | OCl−(aq) and OH−(aq) |
| d. | H2O(l) and HOCl(aq) |

\_\_\_\_ 20. The substance in the equation above that may act as an amphiprotic species is

|  |  |
| --- | --- |
| a. | OCl−(aq) |
| b. | H2O(l) |
| c. | HOCl(aq) |
| d. | OH-(aq) |

\_\_\_\_ 21. The two substances in equimolar amounts that could act as a buffer in this bleach solution are

|  |  |
| --- | --- |
| a. | OCl−(aq) and HOCl(aq) |
| b. | HOCl(aq) and OH−(aq) |
| c. | OCl−(aq) and H2O(l) |
| d. | H2O(l) and OH−(aq) |

*Use the following information to answer the next question.*

|  |
| --- |
| The burning of methane in a Bunsen burner to produce energy can be represented by the equation  CH4(g) + 2 O2(g)  CO2(g) + 2 H2O(g) + energy |

\_\_\_\_ 22. A student determined that the reaction represented by the equation above is **not** at equilibrium because

|  |  |
| --- | --- |
| a. | the system is open |
| b. | a catalyst is not present |
| c. | the temperature is constant |
| d. | both reactants and products are gases |

\_\_\_\_ 23. Which of the following chemical changes would have the greatest percentage of products at equilibrium?

|  |  |
| --- | --- |
| a. | AgCl(s)  Ag+(aq) + Cl−(aq)  Kc = 2.0 x 10-10 |
| b. | BaCO3(s)  Ba2+(aq) + CO32−(aq) Kc = 5.5 x 10-10 |
| c. | HOBr(aq) + H2O(l)  H3O+(aq) + OBr−(aq)   Kc = 2.1 x 10-9 |
| d. | NH2OH(aq) + H2O(l)  NH3OH+(aq) + OH−(aq) Kc = 1.1 x 10-8 |

*Use the following information to answer the next 2 questions.*

|  |
| --- |
| The production of paper can involve the reaction of the hydrated aluminium ion Al(H2O)63+(aq) with water.  Al(H2O)63+(aq) + H2O(l)  Al(OH)(H2O)52+(aq) + H3O+(aq) Kc = 1.4 x 10-5 |

\_\_\_\_ 24. The equilibrium constant expression for this system is

|  |  |
| --- | --- |
| a. |  |
| b. |  |
| c. |  |
| d. |  |

\_\_\_\_ 25. The [H3O+(aq)] in a 0.585 mol/L Al(H2O)63+(aq) solution is

|  |  |
| --- | --- |
| a. | 8.2 x 10-6 mol/L |
| b. | 2.4 x 10-5 mol/L |
| c. | 4.9 x 10-3 mol/L |
| d. | 2.9 x 10-3 mol/L |

*Use the following information to answer the next question.*

|  |
| --- |
| **Red Blood Cells**    **Three Important Equilibria in Blood**  HHb+(aq) + O2(g)  HbO2(aq) + H+(aq)  hemoglobin oxyhemoglobin  H+(aq) + HCO3−(aq)  H2CO3(aq)  H2CO3(aq)  CO2(g) + H2O(l) |

\_\_\_\_ 26. In blood, the [H+(aq)] could be increased by decreasing the

|  |  |
| --- | --- |
| a. | [CO2(g)] |
| b. | [O2(g)] |
| c. | [HCO3−(aq)] |
| d. | [ H2CO3(aq)] |

*Use the following information to answer the next 3 questions.*

|  |
| --- |
| Coal and natural gas contain trace amounts of sulfur compound, which when burned, may lead to acid rain pollution.  **Reactions Related to Acid Rain**  **I** 2 H2S(g) + 3 O2(g)  2 H2O(g) + 2 SO2(g)  **II** 2 SO2(g) + O2(g)  2 SO3(g)  **III** SO2(g) +H2O(l)  H2SO3(aq)  **IV** SO3(g) + H2O(l)  H2SO4(aq) |

\_\_\_\_ 27. The equilibrium law expression for reaction I is

|  |  |
| --- | --- |
| a. |  |
| b. |  |
| c. |  |
| d. |  |

*Use the following information to answer the next question.*

|  |
| --- |
| At 900 K, the equilibrium constant for reaction II is 13.0. The equilibrium concentrations are  [SO2(g)] = 0.361 mol/L  [SO3(g)] = 0.840 mol/L |

\_\_\_\_ 28. Given the values above, the calculated equilibrium concentration of O2(g) is

|  |  |
| --- | --- |
| a. | 0.179 mol/L |
| b. | 0.416 mol/L |
| c. | 2.40 mol/L |
| d. | 5.59 mol/L |

*Use the following information to answer the next question.*

|  |
| --- |
| Some of the SO2(g) produced from the burning of coal and natural gas can react with NO2(g) in the atmosphere according to the equation  SO2(g) + NO2(g)  NO(g) + SO3(g) + 41.9 kJ |

\_\_\_\_ 29. The equilibrium concentration of SO3(g) in the reaction could be increased by

|  |  |
| --- | --- |
| a. | raising the temperature |
| b. | adding a catalyst |
| c. | removing SO2(g) |
| d. | adding NO2(g) |

\_\_\_\_ 30. Indicators are added to three samples of acid rain from the same source. The samples with methyl orange

and chlorophenol red are yellow. The sample with methyl red is red. The approximate pH of the acid rain samples is

|  |  |
| --- | --- |
| a. | 3.0 |
| b. | 4.6 |
| c. | 5.0 |
| d. | 5.5 |

\_\_\_\_ 31. The pH of a lake affected by acid rain could be adjusted to “normal” levels through the addition of

|  |  |
| --- | --- |
| a. | CH3OH(l) |
| b. | HCl(aq) |
| c. | NaCl(aq) |
| d. | CaCO3(s) |

\_\_\_\_ 32. In a highly industrialized area, the rain has an average pH of 4.5, but the pH of the soil has not changed

enough to affect plant growth. The best explanation is that the

|  |  |
| --- | --- |
| a. | soil has a good buffering capacity |
| b. | acid is not completely dissociated |
| c. | plants are resistant to an increase in pH |
| d. | soil has a high concentration of hydronium ions |

\_\_\_\_ 33. The Bronsted-Lowry equation for the dissociation of sulfurous acid in aqueous solution is

|  |  |
| --- | --- |
| a. | H2SO3(aq) + H2O(l)  SO42−(aq) + 4 H+(aq) + 2e− |
| b. | H2SO3(aq) + 2 H2O(l)  SO32−(aq) + 2 H3O+(aq) |
| c. | H2SO3(aq) + H2O(l)  HSO3−(aq) + H3O+(aq) |
| d. | H2SO3(aq)  SO32−(aq) + 2 H+(aq) |

\_\_\_\_ 34. Acid rain in the form of sulfuric acid could be neutralized by

|  |  |
| --- | --- |
| a. | NaCl(s) |
| b. | CaCO3(s) |
| c. | NaHSO4(aq) |
| d. | CH3COOH(aq) |

\_\_\_\_ 35. If the [H3O+(aq)] of a sample of acid rain was determined to be 2.0 x 10-5 mol/L, then the pH and

the pOH are, respectively,

|  |  |
| --- | --- |
| a. | 4.05 and 9.95 |
| b. | 4.40 and 9.60 |
| c. | 4.70 and 9.30 |
| d. | 5.00 and 9.00 |

\_\_\_\_ 36. Which of the following acid solutions has the lowest pH?

|  |  |
| --- | --- |
| a. | 300 mL of 1.00 x 10-2 mol/L H2S(aq) |
| b. | 100 mL of 1.00 x 10-4 mol/L H2SO3(aq) |
| c. | 100 mL of 1.00 x 10-3 mol/L H2SO4(aq) |
| d. | 10.0 mL of 1.00 x 10-4 mol/L H2SO4(aq) |

\_\_\_\_ 37. Acid rain is linked to the leaching of heavy metals and their ions in lakes and rivers. Biomagnification

of these metals and ions increases levels of diseases in fish and wildlife. Based on this information, a

decision to reduce sulfur dioxide emissions would be

|  |  |
| --- | --- |
| a. | political |
| b. | scientific |
| c. | technological |
| d. | environmental |

\_\_\_\_ 38. Another contributor to the acidity of precipitation is CO2(g). Atmospheric CO2(g) levels are not

increased by

|  |  |
| --- | --- |
| a. | photosynthesis |
| b. | combustion of fossil fuels |
| c. | respiration of plants and animals |
| d. | cars equipped with catalytic converters |

\_\_\_\_ 39. When rain containing sulfurous acid falls into lakes containing dissolved calcium carbonate, the pH of

the lake drops slightly and then remains relatively constant. Which of the following statements best

describes a change that occurs in the lake water?

|  |  |
| --- | --- |
| a. | Carbonic acid if formed. |
| b. | The calcium sulfite formed neutralizes the sulfurous acid. |
| c. | The carbonate ion decomposes into carbon dioxide and water. |
| d. | The formation of bicarbonate ion, HCO3−(aq), creates a buffer system with carbonate ion, CO32−(aq) |

\_\_\_\_ 40. Chemical systems reach equilibrium when

|  |  |
| --- | --- |
| a. | no reaction is occurring |
| b. | the rates of forward and reverse reactions become equal |
| c. | the mass of products equals the mass of reactants |
| d. | the number of moles of products equals the number of moles of reactants |

*Use the following information to answer the next question.*

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| --- |
| Nitrogen monoxide, an atmospheric pollutant, can be formed in automobile engines as represented by  the equation N2(g) + O2(g) + 180.4 kJ  2 NO(g) |

\_\_\_\_ 41. The amount of N2(g) at equilibrium can be increased by

|  |  |
| --- | --- |
| a. | increasing the pressure by reducing the volume |
| b. | removing NO(g) |
| c. | adding O2(g) |
| d. | decreasing the temperature |

\_\_\_\_ 42. An ionic solid dissolves and produces an equilibrium system. Which of the following statements about this system is **incorrect**?

|  |  |
| --- | --- |
| a. | The temperature of the solution is constant. |
| b. | No solid is present at the bottom of the container. |
| c. | Vigorous stirring does not dissolve more of the solid. |
| d. | If the solution is heated, the amount of the solid that dissolves changes. |

*Use the following information to answer the next 2 questions.*

|  |
| --- |
| Sodium azide, which is found in automobile air bags, reacts readily with acids to form highly toxic and explosive hydroazoic acid HN3(aq). Hydroazoic acid forms the following equilibrium in water at 25°C.  HN3(aq) + H2O(l)  H3O+(aq) + N3-(aq) Kc = 1.9 x 10-5 |

\_\_\_\_ 43. The Kc expression for hydroazoic acid is

|  |  |  |  |
| --- | --- | --- | --- |
| a. |  | c. |  |
| b. |  | d. |  |

\_\_\_\_ 44. In a solution of hydroazoic acid, the

|  |  |
| --- | --- |
| a. | [HN3(aq)] < [N3-(aq)] |
| b. | [HN3(aq)] > [H3O+(aq)] |
| c. | [HN3(aq)] > [H2O(l)] |
| d. | [HN3(aq)] = [H3O+(aq)] |

*Use the following information to answer the next question.*

|  |
| --- |
| Hydrogen fluoride is produced by reacting hydrogen with fluorine.  H2(g) + F2(g)  2 HF(g) + energy |

\_\_\_\_ 45. A stress that would shift the equilibrium toward the products would be to

|  |  |
| --- | --- |
| a. | remove H2(g) |
| b. | add HF(g) |
| c. | decrease the volume of the reaction vessel |
| d. | decrease the temperature of the reaction vessel |

\_\_\_\_ 46. One of the buffer systems in the human body is

HCO3−(aq) + H2O(l)  H2CO3(aq) + OH−(aq)

This buffer solution would respond to the addition of vinegar, CH3COOH(aq), by

|  |  |
| --- | --- |
| a. | replacing the vinegar with OH-(aq) |
| b. | reacting the vinegar with carbonic acid |
| c. | shifting the equilibrium to the right because [OH-(aq)] would decrease |
| d. | shifting the equilibrium to the left, producing more carbonic acid |

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| In Canada, the annual production of ammonia, NH3(g), exceeds that of any other chemical.  About one-quarter of it is used directly as fertilizer. The rest is used as a reactant in the production  of explosives and chemicals such as nitric acid. One such reaction  4 NH3(g) + 5 O2(g)  4 NO(g) + 6 H2O(g) + energy  is vital to the Ostwald synthesis of nitric acid. |

\_\_\_\_ 47. The equilibrium constant expression for this reaction is

|  |  |  |  |
| --- | --- | --- | --- |
| a. |  | c. |  |
| b. |  | d. |  |

\_\_\_\_ 48. All of the following stresses will cause the equilibrium to shift left **except**

|  |  |
| --- | --- |
| a. | decreasing the volume |
| b. | decreasing the [NO(g)] |
| c. | decreasing the [O2(g)] |
| d. | increasing the temperature |

\_\_\_\_ 49. In a certain experiment, 10 mol of NH3(g) and 25 mol of O2(g) were placed in a 50.0 L reaction vessel and allowed to establish an equilibrium. The row that best represents the concentrations of all components at equilibrium is

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | [NH3(g)] mol/L | [O2(g)] mol/L | [NO(g)] mol/L | [H2O(g)] mol/L |
| **A** | 10 - x | 25 - x | x | x |
| **B** | 10 - 4x | 25 - 5x | 4x | 6x |
| **C** | 0.20 - x | 0.50 - x | x | x |
| **D** | 0.20 - 4x | 0.50 - 5x | 4x | 6x |

*Use the following information to answer the next question.*

|  |
| --- |
| The following graph represents the variation over time of the concentrations of O2(g), SO2(g), and SO3(g) for the reaction 2 SO2(g) + O2(g)  2 SO3(g). |

\_\_\_\_ 50. Which of the following statements about the graph is true?

|  |  |
| --- | --- |
| a. | At t=0, the concentration of SO2(g) is 30 mmol/L. |
| b. | At equilibrium, the concentration of SO2(g) is 30 mmol/L. |
| c. | At equilibrium, the concentration of SO3(g) is 60 mmol/L. |
| d. | At equilibrium, the concentration of SO3(g) is about half that of SO2(g). |

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| In industry, ammonia may be used to manufacture nitric acid through a process called the “Ostwald Process.” The three important reactions involved in this process are summarized by the equations below.  **I** 4 NH3(g) + 5 O2(g)  4 NO(g) + 6 H2O(g)  **II** 2 NO(g) + O2(g)  2 NO2(g)  **III**  3 NO2(g) + H2O(l)  2 HNO3(aq) + NO(g)  In the reaction represented by equation I, a mixture of ammonia and air is passed through a platinum mesh that has been heated to 880°C.  The reaction represented by equation II can be studied in a closed system. A graph of the component concentrations in one such study is shown below. |

\_\_\_\_ 51. In the study, equilibrium was attained after

|  |  |
| --- | --- |
| a. | 4 min |
| b. | 5 min |
| c. | 11 min |
| d. | 12 min |

\_\_\_\_ 52. In the reaction represented by equation III, the yield of nitric acid coud be increased by

|  |  |
| --- | --- |
| a. | replacing the mesh in the system with small platinum pellets |
| b. | decreasing the total pressure of the system by increasing the volume |
| c. | increasing the total pressure of the system by decreasing the volume |
| d. | adding NO(g) to the system |

*Use the following information to answer the next question.*

|  |
| --- |
| In automobile engines, the high operating temperatures cause nitrogen and oxygen in the cylinders to combine to form toxic nitrogen monoxide. To simulate this process in a laboratory, nitrogen and oxygen are combined to form nitrogen monoxide in a closed system. After a period of time, there is evidence that nitrogen monoxide decomposes at the same rate as it forms. |

\_\_\_\_ 53. This laboratory evidence can be communicated chemically as

|  |  |
| --- | --- |
| a. | 2 NO(g) + O2(g)  2NO2(g) |
| b. | N2(g) + O2(g)  2 NO(g) |
| c. | N2(g) + O2(g)  2 NO(g) |
| d. | N(g) + O(g)  NO(g) |

*Use the following information to answer the next three questions.*

|  |
| --- |
| **I** CO2(g) + H2 (g)  CO(g) + H2O(g) Kc = 0.137  **II** CO(g) + H2O(g)  CO2(g) + H2(g) Kc = unknown |

\_\_\_\_ 54. If hydrogen gas is added to reaction I at equilibrium, then the concentration of the carbon dioxide and the value of Kc will

|  |  |
| --- | --- |
| a. | decrease and stay the same, respectively |
| b. | increase and stay the same, respectively |
| c. | increase and decrease, respectively |
| d. | decrease and increase, respectively |

\_\_\_\_ 55. In reaction II, the Kc is

|  |  |
| --- | --- |
| a. | 0.137 |
| b. | -0.137 |
| c. | -7.30 |
| d. | 7.30 |

\_\_\_\_ 56. The following data was obtained when reaction I was at equilibrium

|  |  |  |  |
| --- | --- | --- | --- |
| [CO2(g)] mol/l | [H2(g)] mol/L | [CO(g)] mol/L | [H2O(g)] mol/L |
| ? | 1.50 | 2.50 | 0.250 |

The concentration of CO2(g) in reaction I at equilibrium is

|  |  |
| --- | --- |
| a. | 0.0822 mol/L |
| b. | 0.329 mol/L |
| c. | 3.04 mol/L |
| d. | 12.2 mol/L |

\_\_\_\_ 57. Aqueous solutions of ammonium nitrate are acidic. A 0.20 mol/L solution of NH4NO3(aq) would have a pH of

|  |  |
| --- | --- |
| a. | 0.70 |
| b. | 4.47 |
| c. | 4.97 |
| d. | 5.12 |

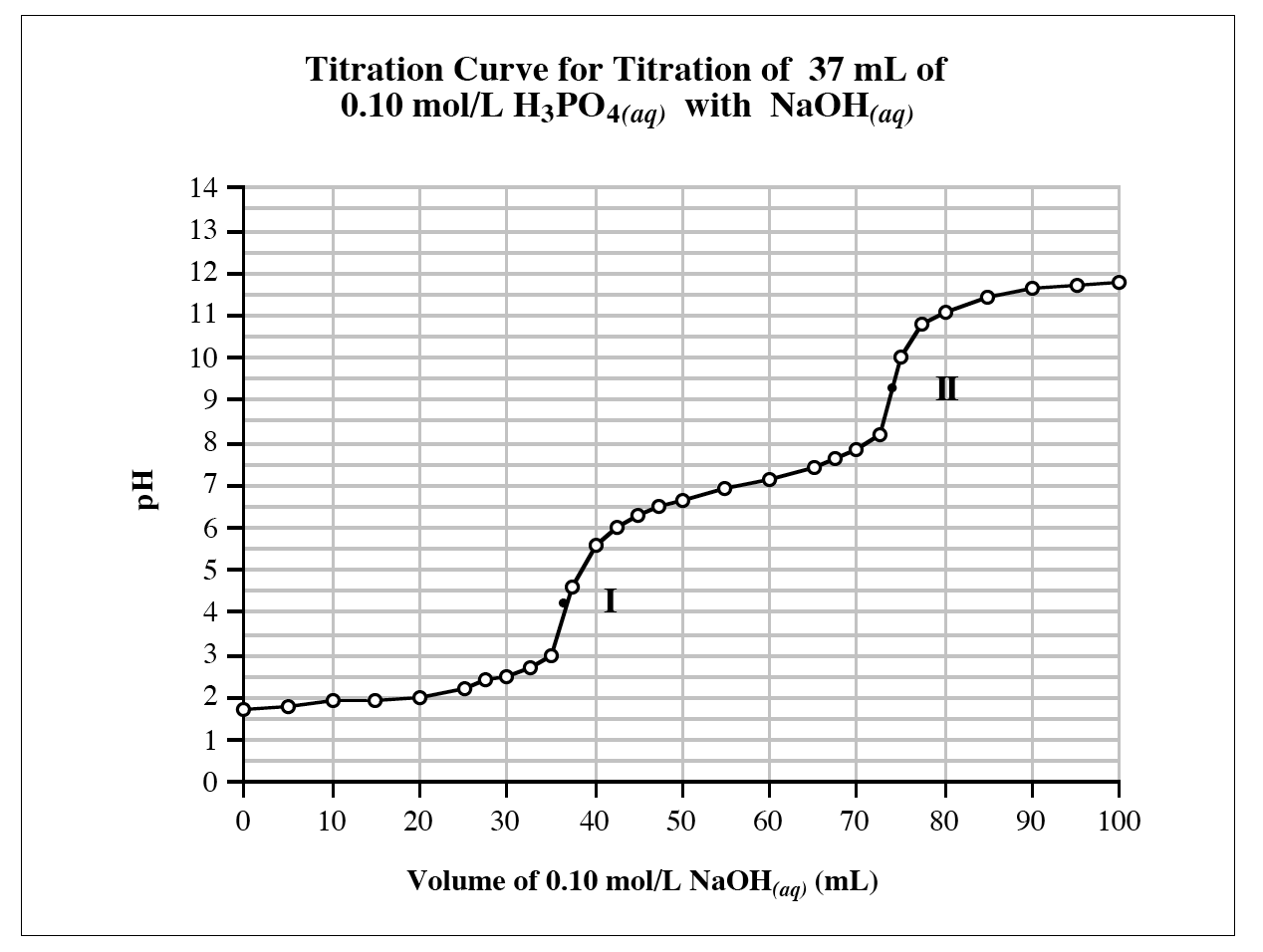
\_\_\_\_ 58. The sketch that indicates the change that occurs when 1.0 mol/L HNO3(aq) is added to 20 mL of 1.0 mol.L NH3(aq) is

|  |  |  |  |
| --- | --- | --- | --- |
| a. |  | c. |  |
| b. |  | d. |  |

\_\_\_\_ 59. A cleaning agent has a pH of 1, and a carbonated beverage has a pH of 5. The cleaning agent is more acidic than the carbonated beverage by a factor of

|  |  |
| --- | --- |
| a. | 10 000 |
| b. | 1 000 |
| c. | 100 |
| d. | 10 |

*Use the following information to answer the next \_\_ questions.*



\_\_\_\_ 60. The Bronsted-Lowry equation for the reaction which takes place in the region between I and II is

|  |  |
| --- | --- |
| a. | H2PO4−(aq) + OH−(aq) ↔ HPO42−(aq) + H2O(l) |
| b. | H3PO4(aq) + OH−(aq) ↔ H2PO4−(aq) + H2O(l) |
| c. | HPO42−(aq) + OH−(aq) ↔ PO43−(aq) + H2O(l) |
| d. | H3PO4(aq) + 2 OH−(aq) ↔ HPO42−(aq) + 2 H2O(l) |

\_\_\_\_ 61. In order to obtain accurate data to calculate the concentration of the H3PO4(aq) solution, all of the indicators listed below **except**

|  |  |
| --- | --- |
| a. | thymol blue |
| b. | bromothymol blue |
| c. | bromocresol green |
| d. | phenolphthalein |

*Use the following information to answer the next question.*

|  |
| --- |
| The water in a swimming pool was tested to determine its pH. Phenolphthalein was colourless in a sample of the water and bromothymol blue was blue. |

\_\_\_\_ 62. The approximate pH of the swimming pool water was

|  |  |
| --- | --- |
| a. | 6.3 |
| b. | 7.0 |
| c. | 8.0 |
| d. | 12.0 |

\_\_\_\_ 63. A substance that can act as either an acid or a base is described as

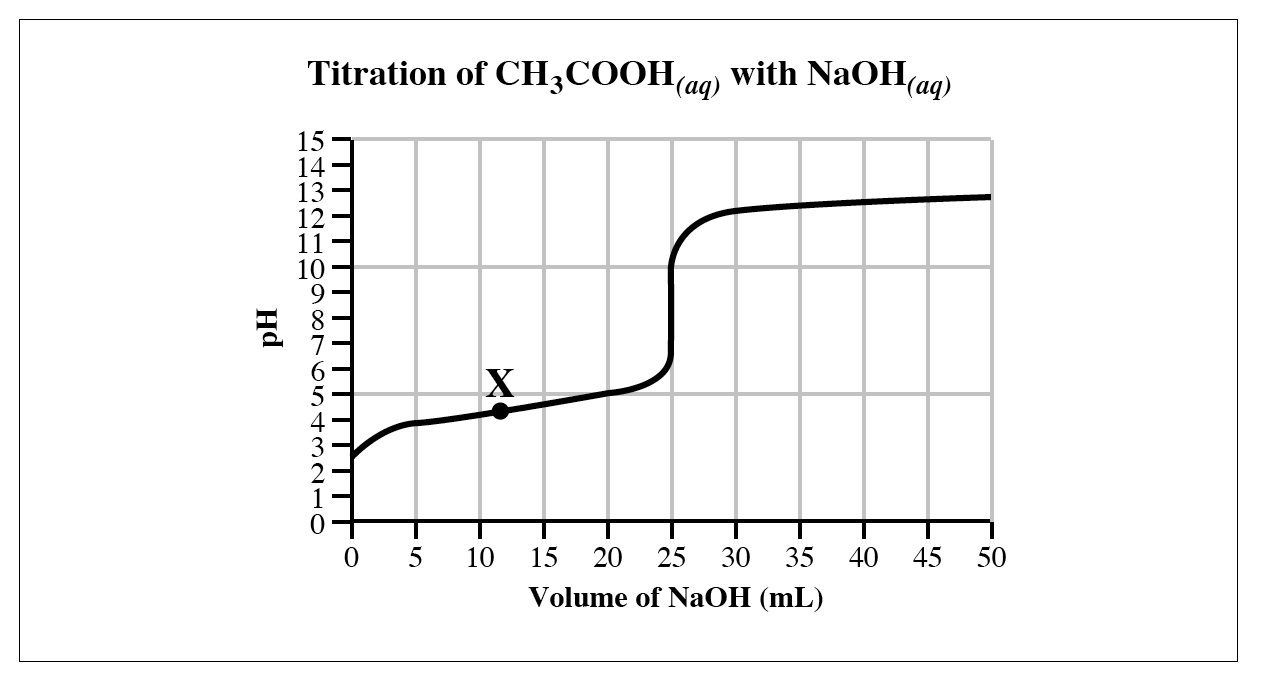
|  |  |
| --- | --- |
| a. | amorphous |
| b. | amphoteric |
| c. | isoprotic |
| d. | allotropic |

\_\_\_\_ 64. When a small amount of base is absorbed into the blood, the H2CO3(aq)/HCO3−(aq) buffer maintains

the blood pH at approximately 7.3 because the base reacts with

|  |  |
| --- | --- |
| a. | H2CO3(aq) |
| b. | HCO3−(aq) |
| c. | CO32−(aq) |
| d. | H2O(l) |

*Use the following information to answer the next question.*



\_\_\_\_ 65. If the titration is stopped at X, the solution is resistant to a change in pH if a strong base or a strong acid is added to it. This is due to the fact that, at X, the solution contains large amounts of

|  |  |
| --- | --- |
| a. | H2O(l) and OH−(aq) |
| b. | CH3COO−(aq) and H3O+(aq) |
| c. | CH3COOH(aq) and OH−(aq) |
| d. | CH3COOH(aq) and CH3OO−(aq) |

*Use the following information to answer the next 3 questions.*

|  |
| --- |
| **Hydrogen Halide Ka**  HF 6.6 x 10-4  HCl 1.3 x 106  HI 3.2 x 109  HBr 1.0 x 109  **Titration of a Halide Acid with 1.0 mol/L NaOH(aq)** |

\_\_\_\_ 66. The hydrogen halides, ordered from the strongest acid to weakest acid, are

|  |  |
| --- | --- |
| a. | HI, HBr, HCl, HF |
| b. | HBr, HI, HCl, HF |
| c. | HBr, HCl, HI, HF |
| d. | HF, HI, HCl, HBr |

\_\_\_\_ 67. The halide acid that would generate the data on the graph is

|  |  |
| --- | --- |
| a. | HF(aq) |
| b. | HCl(aq) |
| c. | HI(aq) |
| d. | HBr(aq) |

\_\_\_\_ 68. The indicator that would best signal the endpoint of this titration is

|  |  |
| --- | --- |
| a. | methyl orange |
| b. | phenolphthalein |
| c. | indigo carmine |
| d. | bromothymol blue |

*Use the following graph to answer the next question.*

|  |
| --- |
|  |

\_\_\_\_ 69. The graph could represent the titration of

|  |  |
| --- | --- |
| a. | sodium hydroxide with hydrochloric acid |
| b. | potassium hydroxide with oxalic acid |
| c. | hydrochloric acid with ammonia |
| d. | acetic acid with sodium hydroxide |

\_\_\_\_ 70. An acid that is not polyprotic is

|  |  |
| --- | --- |
| a. | HOOCCOOH(aq) |
| b. | H2BO3−(aq) |
| c. | HCOOH(aq) |
| d. | H2SO4(aq) |

\_\_\_\_ 71. Which statement for the system

H2PO4−(aq) + CH3COO−(aq) ↔ CH3COOH(aq) + HPO42−(aq) is correct?

|  |  |
| --- | --- |
| a. | H2PO4−(aq) acts as a base. |
| b. | Equilibrium favors the products. |
| c. | CH3COO−(aq) acts as an acid. |
| d. | HPO42−(aq) acts as a base. |

\_\_\_\_ 72. In 0.10 mol/L HCOOH(aq), the species present in the highest concentration is

|  |  |
| --- | --- |
| a. | HCOOH(aq) |
| b. | HCOO−(aq) |
| c. | H3O+(aq) |
| d. | OH−(aq) |

\_\_\_\_ 73. Which concentration of HCl(aq) would yield the same pH as 0.10 mol/L CH3COOH(aq)?

|  |  |
| --- | --- |
| a. | 1.3 mol/L |
| b. | 1.0 x 10-1 mol/L |
| c. | 1.3 x 10-2 mol/L |
| d. | 1.3 x 10-3 mol/L |

\_\_\_\_ 74. Solutions of methanoic acid and sodium ethanoate are mixed. The net ionic equation that best

describes the resulting reaction is

|  |  |
| --- | --- |
| a. | H3O+(aq) + OH−(aq)  H2O(l) + H2O(l) |
| b. | H3O+(aq) + CH3COO−(aq)  CH3COOH(aq) + H2O(l) |
| c. | HCOOH(aq) + CH3COO−(aq) ↔ CH3COOH(aq) + HCOO−(aq) |
| d. | HCOOH(aq) + NaCH3COO(aq) ↔ CH3COOH(aq) + NaHCOO(aq) |

\_\_\_\_ 75. The reaction in which the products are favoured is

|  |  |
| --- | --- |
| a. | H2S(aq) + NO2−(aq) ↔ HS−(aq) + HNO2(aq) |
| b. | HF(aq) + SO42−(aq) ↔ HSO4−(aq) + F−(aq) |
| c. | HCN(aq) + OCl−(aq) ↔ HOCl(aq) + CN−(aq) |
| d. | HCO3−(aq) + PO43−(aq) ↔ CO32−(aq) + HPO42−(aq) |

*Use the following information to answer to answer the next \_ questions.*

|  |
| --- |
| Vinegar, an aqueous solution of acetic acid, is used to preserve and flavour food. Most of the vinegar used for this purpose has an acetic acid concentration of 0.83 mol/L. |

\_\_\_\_ 76. The vinegar used in food as a

|  |  |
| --- | --- |
| a. | [H3O+(aq)] equal to [CH3COO-(aq)] |
| b. | [H3O+(aq)] greater than [CH3COOH(aq)] |
| c. | [CH3COO-(aq)] equal to [CH3COOH(aq)] |
| d. | [CH3COO-(aq)] greater than [H3O+(aq)] |

\_\_\_\_ 77. The [H3O+(aq)] of the 0.83 mol/L CH3COOH(aq) is

|  |  |
| --- | --- |
| a. | 8.3 x 10-1 mol/L |
| b. | 3.9 x 10-3 mol/L |
| c. | 1.8 x 10-5 mol/L |
| d. | 1.5 x 10-5 mol/L |

\_\_\_\_ 78. Vinegar and baking soda (NaHCO3(s)) are added to recipes to produce baked products with light,

fluffy textures. The net ionic equation for the reaction that occurs is

|  |  |
| --- | --- |
| a. | H3O+(aq) + HCO3−(aq)  CO2(g) + 2 H2O(l) |
| b. | HCO3−(aq) + CH3COO−(aq)  CH3COOH(aq) + CO32−(aq) |
| c. | CH3COOH(aq) + NaHCO3(aq)  NaCH3COO(aq) + CO2(g) + H2O(l) |
| d. | CH3COOH(aq) + HCO3−(aq)  CH3COO−(aq) + CO2(g) + H2O(l) |

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| HNO2(aq) + H2BO3−(aq)  NO2−(aq) + H3BO3(aq) |

\_\_\_\_ 79. A conjugate acid-base pair in the reaction is

|  |  |
| --- | --- |
| a. | H2BO3−(aq) and NO2−(aq) |
| b. | H3BO3(aq) and H2BO3−(aq) |
| c. | HNO2(aq) and H2BO3−(aq) |
| d. | H3BO3(aq) and NO2−(aq) |

\_\_\_\_ 80. The amphiprotic species in the reaction is

|  |  |
| --- | --- |
| a. | H2BO3−(aq) |
| b. | HNO2(aq) |
| c. | NO2−(aq) |
| d. | H3BO3(aq) |

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| Solutions of carbolic acid, commonly known as phenol (HC6H5O(aq)), are widely used as disinfectants. One such solution has a concentration of 6.44 x 10-2 mol/L and a pH of 5.60. Carbolic acid dissociates in water according to the equation  HC6H5O(aq) + H2O(l)  C6H5O−(aq) + H3O+(aq) |

\_\_\_\_ 81. The Ka expression for the equation is

|  |  |  |  |
| --- | --- | --- | --- |
| a. |  | c. |  |
| b. |  | d. |  |

\_\_\_\_ 82. The Ka for this carbolic acid is

|  |  |
| --- | --- |
| a. | 6.3 x 10-12 |
| b. | 9.8 x 10-11 |
| c. | 2.5 x 10-6 |
| d. | 3.9 x 10-5 |

\_\_\_\_ 83. In the *CRC Handbook of Chemistry and Physics*, the Ka for carbolic acid at 20.0°C is 1.3 x 10-10. The Kb for C6H5O−(aq) is

|  |  |
| --- | --- |
| a. | 1.1 x 10-12 |
| b. | 1.1 x 10-5 |
| c. | 7.7 x 10-5 |
| d. | 1.3 x 10-10 |

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| Beverages such as carbonated soft drinks contain carbonic acid. In addition, citric acid and phosphoric acid are often added to ensure that the pH is below 4.5. This is considered the “safety zone” for these beverages because below this pH, the risk of microbial contamination is very low. |

\_\_\_\_ 84. The equation representing the equilibrium of phosphoric acid is

|  |  |
| --- | --- |
| a. | H3PO4(aq) + H2O(l)  H2PO4−(aq) + OH−(aq) |
| b. | H3PO4(aq)  H3O+(aq) + PO3−(aq) |
| c. | H3PO4(aq)  3 H+(aq) + PO43−(aq) |
| d. | H3PO4(aq) + H2O(l)  H2PO4−(aq) + H3O+(aq) |

*Use the following additional information to answer the next question.*

|  |
| --- |
| A student sketched a titration curve based on data collected during a reaction between a 0.050 mol.L NaOH(aq) titrant and a 25.0 mL sample of a soft drink. |

\_\_\_\_ 85. The most suitable indicator to identify the equivalence point of the second reaction is

|  |  |
| --- | --- |
| a. | phenolphthalein |
| b. | bromothymol blue |
| c. | methyl red |
| d. | methyl orange |

\_\_\_\_ 86. A glass of orange juice contains enough hydronium ions to kill you if your blood is not buffered to a pH of about 7.35. One of the several buffers systems that your blood contains is H2PO4−(aq)/HPO42−(aq). This system initially buffers the addition of hydronium ions from orange juice by the reaction

|  |  |
| --- | --- |
| a. | H3O+(aq) + H2PO4−(aq)  H3PO4(aq) + H2O(l) |
| b. | H3O+(aq) + HPO42−(aq)  H2PO4−(aq) + H2O(l) |
| c. | 2 H3O+(aq) + PO43−(aq)  H2PO4−(aq) + 2 H2O(l) |
| d. | 2 H3O+(aq) + 2 H2PO4−(aq)  PO43−(aq) + 2 H2O(l) |

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| Hot tub owners can control disease-causing bacteria and algae by adding solid sodium hypochlorite pellets, NaClO(s), to the water. This results in the formation of HClO(aq), as represented by the equilibrium  ClO−(aq) + H2O(l)  HClO(aq) + OH−(aq)  Undissociated HClO(aq) effectively kills bacteria and algae. A pH of 7.40 is considered ideal for a hot tub. |

\_\_\_\_ 87. Ideally, the water in a hot tub has a hydronium ion concentration of

|  |  |
| --- | --- |
| a. | 4.0 x 10-8 mol/L and is basic. |
| b. | 2.5 x 10-7 mol.L and is basic. |
| c. | 4.0 x 10-8 mol/L and is acidic. |
| d. | 2.5 x 10-7 mol/L and is acidic. |

\_\_\_\_ 88. When using a hot tub, bathers release substances from their bodies into the water that result in an increase in the pH of the water. As the pH increases, there is \_\_\_ *i*\_\_\_ in [H3O+(aq)], which results in an equilibrium shift that is \_\_\_*ii*\_\_\_ favourable to bacterial growth.

|  |  |  |
| --- | --- | --- |
|  | *i* | *ii* |
| A. | an increase | more |
| B. | a decrease | more |
| C. | an increase | less |
| D. | a decrease | less |

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| Body chemistry involves a number of chemical systems that are critically dependent on pH, buffering action, and concentration of gas solutes such as CO2(g) and O2(g). |

\_\_\_\_ 89. The function of chemical buffers in the blood is to

|  |  |
| --- | --- |
| a. | control all reactions. |
| b. | act as catalysts to increase the rate of reaction. |
| c. | withstand the continual addition of acid or base. |
| d. | maintain a constant pH when a small amount of acid or base is added. |

\_\_\_\_ 90. One of the buffers present in blood is

|  |  |
| --- | --- |
| a. | HSO3−(aq), H2SO3(aq) |
| b. | HCO3−(aq), H2CO3(aq) |
| c. | NO3−(aq), HNO3(aq0 |
| d. | Cl−(aq), HCl(aq) |

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| Methanoic (formic) acid is the irritant secreted during an ant bite. The irritation is partially due to the ionization of methanoic acid. The equilibrium equation for the ionization can be represented as HCOOH(aq) + H2O(l)  H3O+(aq) + HCOO-(aq) |

\_\_\_\_ 91. Which of the substances in the equation above could function as an amphiprotic species?

|  |  |
| --- | --- |
| a. | HCOOH(aq) |
| b. | H2O(l) |
| c. | H3O+(aq) |
| d. | HCOO−(aq) |

\_\_\_\_ 92. In a comparison of the species present in HCOOH(aq), the

|  |  |
| --- | --- |
| a. | [H3O+(aq)] is greater than the [HCOOH(aq)] |
| b. | [H3O+(aq)] is equal to the [HCOOH(aq)] |
| c. | [HCOOH(aq)] is greater than the [HCOO−(aq)] |
| d. | [HCOOH(aq)] is equal to the [HCOO−(aq)] |

\_\_\_\_ 93. The [OH-(aq)] in 0.10 mol/L NaHCOO(aq) is

|  |  |
| --- | --- |
| a. | 1.3 x 10−2 mol/L |
| b. | 4.2 x 10−3 mol/L |
| c. | 2.4 x 10−6 mol/L |
| d. | 7.5 x 10−6 mol/L |

\_\_\_\_ 94. Methanoic acid slowly decomposes to form CO(g) and H2O(l). The rate of reaction is increased if a catalyst is present. Compared with the uncatalyzed reaction, the catalyzed reaction has

|  |  |
| --- | --- |
| a. | the same Kc. |
| b. | a larger Kc. |
| c. | a faster forward reaction. |
| d. | a slower forward reaction. |

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| Ethanoic acid (vinegar) has a variety of uses. To ensure that production plants meet concentration specifications, technicians monitor the concentration of the acid by titrating samples of the ethanoic acid as it comes off the production line.  **Titration of 10.0 mL of CH3COOH(aq) with 0.20 mol/L NaOH(aq)** |

\_\_\_\_ 95. On this graph, the equivalence point is indicated by Roman numeral

|  |  |
| --- | --- |
| a. | I |
| b. | II |
| c. | III |
| d. | IV |

\_\_\_\_ 96. On this graph, the buffering region is indicated by Roman numeral

|  |  |
| --- | --- |
| a. | I |
| b. | II |
| c. | III |
| d. | IV |

\_\_\_\_ 97. The best indicator for this titration is

|  |  |
| --- | --- |
| a. | indigo carmine |
| b. | phenolphthalein |
| c. | bromothymol blue |
| d. | bromocresol green |

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| Sodium hydrogen carbonate, NaHCO3(s) (baking soda) is used in baking. When lactic acid, HC3H5O3(aq), and baking soda are present, they cause dough’s and batters to rise. Lactic acid, a component of buttermilk, has a Ka = 1.4 x 10-4. |

\_\_\_\_ 98. The net ionic equation that best illustrates the reaction responsible for the dough rising is

|  |  |
| --- | --- |
| a. | H3O+(aq) + HCO3−(aq)  CO2(g) + 2 H2O(l) |
| b. | HCO3−(aq) + C3H5O3−(aq)  HC3H5O3(aq) + CO32−(aq) |
| c. | NaHCO3(aq) + H3O+(aq)  H2CO3(aq) + H2O(l) + Na+(aq) |
| d. | HCO3−(aq) + HC3H5O3(aq)  H2O(l) + CO2(g) + C3H5O3−(aq) |

\_\_\_\_ 99. The [H3O+(aq)] in 0.20 mol/L HC3H5O3(aq) is

|  |  |
| --- | --- |
| a. | 2.8 x 10-3 mol/L |
| b. | 5.3 x 10-3 mol/L |
| c. | 2.6 x 10-2 mol/L |
| d. | 7.0 x 10-4 mol/L |

*Use the following information to answer the next question.*

|  |
| --- |
| Exterminators sometimes use hydrogen cyanide gas to eliminate vermin such as rats from buildings. The deadly gas is produced by dissolving pellets of NaCN(s) in HCl(aq). |

\_\_\_\_ 100. A balanced net ionic equation for the reaction that produces this gas is

|  |  |
| --- | --- |
| a. | CN−(aq) + 3 H+(aq) + 2 e−  HCN(g) + H2(g) |
| b. | NaCN(aq) + HCl(aq)  HCN(g) + NaCl(aq) |
| c. | CN−(aq) + H2O(l)  HCN(g) + OH−(aq) |
| d. | CN−(aq) + H3O+(aq)  HCN(g) + H2O(l) |

*Use the following information to answer the next question.*

|  |
| --- |
| Morphine (Mor(aq)) is a narcotic prescribed to patients to diminish severe pain. Morphine can react with water, as represented by the equilibrium  Mor(aq) + H2O(l)  HMor+(aq) + OH−(aq) |

\_\_\_\_ 101. A 0.100 mol/L sample of Mor(aq) with a pH of 11.426 has a OH−(aq) concentration of

|  |  |
| --- | --- |
| a. | 3.75 x 10−12 mol/L |
| b. | 1.94 x 10−6 mol/L |
| c. | 2.67 x 10−3 mol/L |
| d. | 1.00 x 10−1 mol/L |

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| The disagreeable odour of rancid butter is caused in part by the presence of butanoic acid (C3H7COOH(aq)). The Ka vale for C3H7COOH(aq) at 25°C is 1.5 x 10-5. |

\_\_\_\_ 102. The hydronium ion concentration in a 0.10 mol/L C3H7COOH(aq) solution is

|  |  |
| --- | --- |
| a. | 1.2 x 10−3 mol/L |
| b. | 1.5 x 10−6 mol/L |
| c. | 7.5 x 10−7 mol/L |
| d. | 6.7 x 10−10 mol/L |

\_\_\_\_ 103. The conjugate base of butanoic acid is

|  |  |
| --- | --- |
| a. | C3H8COOH(aq) |
| b. | C3H7COOH+(aq) |
| c. | C3H7COO(aq) |
| d. | C3H7COO−(aq) |

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| Oxalic acid is used in wooden deck cleaners because it is a good bleaching and cleaning agent. In a beaker containing oxalic acid, the following equilibria occur.  HOOCCOOH(aq) + H2O(l)  H3O+(aq) + HOOCCOO−(aq)  HOOCCOO−(aq) + H2O(l)  H3O+(aq) + OOCCOO2−(aq) |

\_\_\_\_ 104. In an oxalic acid solution, the species with the **lowest** concentration is

|  |  |
| --- | --- |
| a. | H3O+(aq) |
| b. | OOCCOO2−(aq) |
| c. | HOOCCOO−(aq) |
| d. | HOOCCOOH(aq) |

\_\_\_\_ 105. The concentration of an oxalic acid solution can be determined by titrating it with sodium hydroxide. Which of the following pH curves would be expected for the titration of oxalic acid with sodium hydroxide?

|  |  |  |  |
| --- | --- | --- | --- |
| a. |  | c. |  |
| b. |  | d. |  |

\_\_\_\_ 106. At the start of the titration of oxalic acid with sodium hydroxide, the pH of the reaction mixture changes very little when a small volume of the strong base is added. The **best** explanation for why this change is slight is that

|  |  |
| --- | --- |
| a. | oxalic acid is polyprotic |
| b. | oxalic acid is amphiprotic |
| c. | a buffer is produced during the titration |
| d. | oxalic acid has a relatively small Ka value |

\_\_\_\_ 107. A polyprotic species and an amphiprotic species are, respectively,

|  |  |
| --- | --- |
| a. | OOCCOO2−(aq) and HOOCCOOH(aq) |
| b. | HOOCCOOH(aq) and OOCCOO2−(aq) |
| c. | HOOCCOO−(aq) and HOOCCOOH(aq) |
| d. | HOOCCOOH(aq) and HOOCCOO−(aq) |

\_\_\_\_ 108. The Kb for the OOCCOO2−(aq) ion is

|  |  |
| --- | --- |
| a. | 1.5 x 1010 |
| b. | 1.5 x 10-4 |
| c. | 6.7 x 10-11 |
| d. | 1.8 x 10-13 |

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| Body hair can be removed by using a chemical hair removal cream. One form of the cream contains sodium sulfide, calcium sulfide, and strontium sulfide. The sulfide ions in the cream will react with water, as represented by the following equation.  **Hair Removal Reaction**  S2−(aq) + H2O(l)  HS−(aq) + OH−(aq)  The solution resulting from the reaction will break some of the bonds in the hair, which allows the hair to be washed away. |

\_\_\_\_ 109. *In the hair removal reaction, the sulfide ion acts as a Bronsted-Lowry \_\_\_i\_\_\_ and \_\_\_ii\_\_\_ a proton.*

The statement above is completed by the information in row

|  |  |  |
| --- | --- | --- |
| **Row** | **i** | **ii** |
| **A.** | acid | donates |
| **B.** | acid | accepts |
| **C.** | base | donates |
| **D.** | base | accepts |

*Use this additional information to answer the next question.*

|  |  |
| --- | --- |
| **Acid Formula** | **Conjugate Base Formula** |
| H2S(aq) | HS−(aq) |
| HS−(aq) | S2−(aq) |

\_\_\_\_ 110. Which of the following statements about equilibrium constants applies to the ionization of H2S(aq)?

|  |  |
| --- | --- |
| a. | The Kb of S2−(aq) is less than the Kb of HS−(aq). |
| b. | The Ka of HS−(aq) is greater than the Ka of H2S(aq). |
| c. | The Kb of HS−(aq) is less than the Ka of H2S(aq). |
| d. | The Kb of S2−(aq) is greater than the Kb of HS−(aq). |

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| Sulfur dioxide gas can be collected and used in the manufacturing of sulfuric acid. The equation that represents the manufacturing of sulfuric acid is represented below.  2 SO2(g) + O2(g) + 2 H2O(l)  2 H2SO4(aq) |

\_\_\_\_ 111. Which of the following statements describes what happens to the solution during the manufacturing of sulfuric acid?

|  |  |
| --- | --- |
| a. | The pH of the solution will increase as the acidity of the solution increases. |
| b. | The pH of the solution will increase as the basicity of the solution increases. |
| c. | The pOH of the solution will increase as the acidity of the solution increases. |
| d. | The pOH of the solution will approach 7 as the basicity of the solution increases. |

*Use the following information to answer the next question.*

|  |
| --- |
| A buffer system present in some of Alberta’s lakes consists of HCO3−(aq) and CO32−(aq), as represented by the equilibrium  HCO3(aq) + H2O(l)  H3O+(aq) + CO32−(aq) |

\_\_\_\_ 112. The graph that best represents the titration of the CO32−(aq) / HCO3−(aq) buffer with NaOH(aq) is

|  |  |  |  |
| --- | --- | --- | --- |
| a. |  | c. |  |
| b. |  | d. |  |

*Use the following information to answer the next question.*

|  |
| --- |
|  |

\_\_\_\_ 113. The beakers that best represent a buffer solution in which HA(aq) is a weak acid are those labelled

|  |  |
| --- | --- |
| a. | I and II |
| b. | I and III |
| c. | II and III |
| d. | III and IV |

*Use the following information to answer the next question.*

|  |
| --- |
| **Oxoacids of Chlorine**  **Acid Ka**  HClO4(aq) very large  HClO3(aq) 5.1 x 102  HClO2(aq) 1.1 x 10−2  HClO(aq) 2.9 x 10−8 |

\_\_\_\_ 114. Acids are classified as either strong or weak. Of the acids listed above, only

|  |  |
| --- | --- |
| a. | HClO(aq) is a strong acid |
| b. | HClO4(aq) is a strong acid |
| c. | HClO4(aq) and HClO3(aq) are strong acids |
| d. | HClO4(aq), HClO3(aq), and HClO2(aq) are strong acids |

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| To determine the identity of a compound, a student dissolved 0.72 g of the compound in enough water to make a 25 mL solution. This solution was titrated with a 0.20 mol/L standardized solution. The student used a pH meter to collect data during the titration and then plotted the data on the graph below.  **Titration of the Solution** |

\_\_\_\_ 115. This titration likely involved a

|  |  |
| --- | --- |
| a. | strong base added to a strong acid |
| b. | strong base added to a weak acid |
| c. | strong acid added to a strong base |
| d. | strong acid added to a weak base |

\_\_\_\_ 116. The pH of the solution at the equivalence point for this titration is approximately

|  |  |
| --- | --- |
| a. | 4.5 |
| b. | 8.5 |
| c. | 11.5 |
| d. | 13.5 |

\_\_\_\_ 117. For this titration, a suitable indicator and its corresponding colour change are

|  |  |
| --- | --- |
| a. | phenolphthalein and colourless to pink |
| b. | indigo carmine and blue to yellow |
| c. | thymol blue and blue to yellow |
| d. | phenol red and red to yellow |

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| If H2S(g) is released into the atmosphere, it dissolves in atmospheric water to form hydrosulfuric acid. The ionization of H2S(aq) can be represented by the equilibrium  H2S(aq) + H2O(l)  HS−(aq) + H3O+(aq) |

\_\_\_\_ 118. The Ka expression for this ionization is

|  |  |  |  |
| --- | --- | --- | --- |
| a. |  | c. |  |
| b. |  | d. |  |

\_\_\_\_ 119. The [H3O+(aq)] in a 0.050 mol/L H2S(aq) solution is

|  |  |
| --- | --- |
| a. | 5.5 x 10−9 mol/L |
| b. | 6.7 x 10−5 mol/L |
| c. | 3.3 x 10−4 mol/l |
| d. | 0.10 mol/L |

\_\_\_\_ 120. Chloroacetic acid (CH2ClCOOH(aq)) has a Ka = 1.4 x 10−3. This acid could best be described as

|  |  |
| --- | --- |
| a. | weak inorganic acid |
| b. | diprotic organic acid |
| c. | weak monoprotic acid |
| d. | strong monoprotic acid |

\_\_\_\_ 121. In the equation HNO3(aq) + N2H4(aq)  NO3−(aq) + N2H5+(aq), on conjugate acid-base pair is

|  |  |
| --- | --- |
| a. | HNO3(aq) and N2H5+(aq) |
| b. | HNO3(aq) and N2H4(aq) |
| c. | N2H4(aq) and N2H5+(aq) |
| d. | N2H4(aq) and NO3-(aq) |

*Use the following information to answer the next two questions.*

|  |
| --- |
| A group of students performed a titration and graphed their results, as shown below.  **Acid-Base Titration Curve** |

\_\_\_\_ 122. From this graph, the pH at the equivalence point is approximately

|  |  |
| --- | --- |
| a. | 1 |
| b. | 2 |
| c. | 7 |
| d. | 13 |

\_\_\_\_ 123. This titration curve represents the addition of a

|  |  |
| --- | --- |
| a. | strong base to a strong acid |
| b. | weak base to a strong acid |
| c. | strong acid to a strong base |
| d. | weak acid to a strong base |

\_\_\_\_ 124. Sour pickles have a pH of about 3.00. The [OH−(aq] in a typical sour pickle is

|  |  |
| --- | --- |
| a. | 1.0 x 10-11 mol/L |
| b. | 3.0 x 10-11 mol/L |
| c. | 1.0 x 10-3 mol/L |
| d. | 3.0 x 10-3 mol/L |

\_\_\_\_ 125. An equilibrium that would favour the products is

|  |  |
| --- | --- |
| a. | NH4+(aq) + H2PO4−(aq)  NH3(aq) + H3PO4(aq) |
| b. | HCN(aq) + HS−(aq)  CN−(aq) + H2S(aq) |
| c. | HCO3−(aq) + PO43−(aq)  HPO42-(aq) + CO32−(aq) |
| d. | HSO4−(aq) + HSO3−(aq)  H2SO3(aq) + SO42−(aq) |

\_\_\_\_ 126. Which of the following mixtures could act as a buffer?

|  |  |
| --- | --- |
| a. | HF(aq) and H2S(aq) |
| b. | NaOH(aq) and HCl(aq) |
| c. | Na2CO3(aq) and NH3(aq) |
| d. | NaH2BO3(aq) and Na2HBO3(aq) |

\_\_\_\_ 127. One important buffer that exists in blood is composed of H2PO4−(aq) and HPO42−(aq). The net ionic equation that represents the reaction of hydrochloric acid with this buffer is

|  |  |
| --- | --- |
| a. | H3O+(aq) + HPO42−(aq)  H2O(l) + H2PO4−(aq) |
| b. | HCl(aq) + H2PO4−(aq) Cl−(aq) + H3PO4(aq) |
| c. | H3O+(aq) + H2PO4−(aq)  H2O(l) + H3PO4(aq) |
| d. | HCl(aq) + HPO42−(aq)  Cl−(aq) + H2PO4−(aq) |

*Use the following information to answer the next question.*

|  |
| --- |
| When 20.0 mL of 0.10 mol/L solution of NaHCO3(aq), NaHS(aq), NaOCl(aq), and Na2C6H6O6(aq) were each reacted with 20.0 mL of 0.10 mol/L HBrO(aq), the following positions of equilibrium were established.  HCO3−(aq) + HBrO(aq)  favours reactants  HS−(aq) + HBrO(aq)  favours reactants  OCl−(aq) + HBrO(aq)  favours reactants  C6H6O62−(aq) + HBrO(aq)  favours reactants |

\_\_\_\_ 128. Based on these positions, the placement of HBrO(aq) on the Relative Strengths of Acids and Bases chart is

|  |  |
| --- | --- |
| a. | below hydrogen ascorbate ion |
| b. | above carbonic acid |
| c. | below hypochlorous acid |
| d. | above hydrosulfuric acid |

*Use the following information to answer the next 2 questions.*

|  |
| --- |
| The main buffer solution of plasma and tissue fluid found in our bodies is H2CO3(aq)-HCO3−(aq).  **pH of Blood Effect**  7.50 alkalosis (life threatening)    7.35 *healthy individual*    acidosis (life threatening) |

\_\_\_\_ 129. Which of the following substances can be added to the blood of a young child with kidney disease in order to control acidosis?

|  |  |
| --- | --- |
| a. | CO2(g) |
| b. | HCO3−(aq) |
| c. | H2O(l) |
| d. | H2CO3(aq) |

\_\_\_\_ 130. When excess hydronium ions enter our blood, the equation that represents the reaction that occurs is

|  |  |
| --- | --- |
| a. | H3O+(aq) + OH−(aq)  2 H2O(l) |
| b. | H2CO3(aq) + OH−(aq)  HCO3−(aq) + H2O(l) |
| c. | H2CO3(aq) + H2O(l)  H3O+(aq) + HCO3−(aq) |
| d. | H3O+(aq) + HCO3−(aq)  H2CO3(aq) + H2O(l) |

\_\_\_\_ 131. Hyperventilation (very rapid, deep breathing) results in rapid loss of CO2(g) from our bodies. During hyperventilation, the pH of blood

|  |  |
| --- | --- |
| a. | decreases |
| b. | increases |
| c. | remains at normal levels |
| d. | becomes more dilute |

\_\_\_\_ 132. A reaction favouring reactants in which HCO3−(aq) acts as an acid is

|  |  |
| --- | --- |
| a. | HCO3−(aq) + C6H6O62-(aq)  HC6H6O6−(aq) + CO32−(aq) |
| b. | HCO3−(aq) + HPO42−(aq)  H2PO4−(aq) + CO32−(aq) |
| c. | HCO3−(aq) + CH3COOH(aq)  H2CO3(aq) + CH3COO−(aq) |
| d. | HCO3−(aq) + HSO4−(aq)  H2CO3(aq) + SO42−(aq) |

*Use the following information to answer the next question.*

|  |
| --- |
| **Titration Plot for 25.0 mL of 0.100 mol/L NH3(aq) with 0.100 mol/L HCl(aq)** |

\_\_\_\_ 133. The most suitable indicator for the titration is

|  |  |
| --- | --- |
| a. | phenolphthalein |
| b. | methyl violet |
| c. | chlorophenol red |
| d. | methyl orange |

\_\_\_\_ 134. When citric acid combines with water in the mouth, one reaction that occurs is

H3C6H5O7(aq) + H2O(l)  H2C6H5O7−(aq) + H3O+(aq)

The conjugate acid-base pairs in this equation are

|  |  |
| --- | --- |
| a. | H3C6H5O7(aq)/H3O+(aq) and H2O(l)/H2C6H5O7−(aq) |
| b. | H3C6H5O7(aq)/HC6H5O72−(aq) and H2O(l)/H3O+(aq) |
| c. | H3C6H5O7(aq)/H2O(l) and H2C6H5O7−(aq)/H3O+(aq) |
| d. | H3C6H5O7(aq)/H2C6H5O7−(aq) and H3O+(aq)/H2O(l) |

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| Anthocyanins (represented as A+(aq)) are responsible for the red colour of wine. Anthocyanins react with water as follows  2 H2O(l) + A+(aq)  H3O+(aq) + AOH(aq)  The AOH(aq) form is colourless. In a particular white wine sample, the equilibrium [H3O+(aq)] is 8.5 x 10-4 mol/L. |

\_\_\_\_ 135. If the initial concentration of anthocyanins, prior to equilibrium, was 1.62 x 10-3 mol/L, the Ka for anthocyanins is

|  |  |
| --- | --- |
| a. | 2.24 x 103 |
| b. | 1.07 x 101 |
| c. | 9.38 x 10-4 |
| d. | 4.46 x 10-4 |

\_\_\_\_ 136. A solution of hydrocyanic acid has a pH of 4.80. The concentration of the HCN(aq) solution is

|  |  |
| --- | --- |
| a. | 0.16 mol/L |
| b. | 0.25 mol/L |
| c. | 0.41 mol/L |
| d. | 0.65 mol/L |

\_\_\_\_ 137. What type of solution could have a pH greater than 14?

|  |  |
| --- | --- |
| a. | A dilute weak base. |
| b. | A dilute strong base. |
| c. | A concentrated strong base. |
| d. | No solution could have a pH greater than 14. |

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| HPABA (para-amino benzoic acid) is a weak monoprotic acid whose salts are commonly used as a sunblock. HPABA(aq) at 25°C has a Ka = 1.20 x 10−5. |

\_\_\_\_ 138. If the concentration of HPABA(aq) and the concentration of each of the following acids are the same, then the acid that would have a higher pH than HPABA(aq) is

|  |  |
| --- | --- |
| a. | nitric acid |
| b. | benzoic acid |
| c. | methanoic acid |
| d. | hydrocyanic acid |

\_\_\_\_ 139. The conjugate base of HPABA(aq) is PABA−(aq). The Kb of PABA−(aq) is

|  |  |
| --- | --- |
| a. | 1.20 x 109 |
| b. | 5.00 x 10-2 |
| c. | 8.33 x 10-10 |
| d. | 1.20 x 10-19 |

\_\_\_\_ 140. The PABA-(aq) in sunscreens may react with the lactic acid (HLac(aq)), found in perspiration. This reaction can be represented by the following equilibrium equation

PABA−(aq) + HLac(aq)  HPABA(aq) + Lac−(aq)

The Bronsted-Lowry acids in this equilibrium equation are

|  |  |
| --- | --- |
| a. | HLac(aq) and Lac−(aq) |
| b. | PABA−(aq) and HLac(aq) |
| c. | HLac(aq) and HPABA(aq) |
| d. | PABA−(aq) and HPABA(aq) |

\_\_\_\_ 141. When carbonic acid in the blood dissociates, excess hydronium ions ae excreted through the kidneys. In the kidneys, urine contains an NH3(aq)/NH4+(aq) buffer. An equation that represents the reaction between th excess hydronium ions and the buffer is

|  |  |
| --- | --- |
| a. | NH3(aq) + H3O+(aq)  NH4+(aq) + H2O(l) |
| b. | NH4+(aq) + OH−(aq)  NH3(aq) + H2O(l) |
| c. | NH3(aq) + H2CO3(aq)  NH4+(aq) + HCO3−(aq) |
| d. | NH4+(aq) + HCO3−(aq)  NH3(aq) + H2CO3(aq) |

*Use the following information to answer the next question.*

|  |
| --- |
| The following pH curve represents the changes in pH during a titration of the weak diprotic acid H2A(aq) with a sodium hydroxide solution.  **Titration of H2A(aq) with NaOH(aq)** |

\_\_\_\_ 142. Regions I and II above represent the reaction of NaOH(aq) with the primary species

|  |  |
| --- | --- |
| a. | H2A(aq) and HA−(aq), respectively |
| b. | H3O+(aq) and HA−(aq), respectively |
| c. | HA−(aq) and A2−(aq), respectively |
| d. | H3O+(aq) and A2−(aq), respectively |

**Numeric Response**

*Use the following information to answer the next \_ question.*

|  |
| --- |
| The overall reaction in the Haber-Bosch process for the production of ammonia is  N2(g) + 3 H2(g)  2 NH3(g)  Data for this equilibrium system was collected and plotted on a graph by a student. |

143. The minimum time, in minutes, required to establish equilibrium is \_\_\_\_\_\_\_ min.

*(Record your three digit answer in the numeric response section.)*

144. The equilibrium constant for this system is \_\_\_\_\_\_\_\_\_\_.

*(Record your three digit answer in the numeric response section.)*

*Use the following information to answer the next question.*

|  |
| --- |
| A source of hydrogen for the Haber process is “syngas” which is produced by a reaction of methane and water at 1 000°C.  CH4(g) + H2O(g) + heat  CO(g) + 3 H2(g) |

145. If at equilibrium, the [CH4(g)] = 2.97 mol/L, [H2O(g)] = 7.94 mol/L, [CO(g)] = 5.45 mol/L, and [H2(g)] = 2.10 mol/L, then the Kc is \_\_.

*(Record your three digit answer in the numeric response section.)*

*Use the following information to answer the next question.*

|  |
| --- |
| **Manipulations of an Equilibrium System**  CH4(g) + H2O(g) + heat  CO(g) + 3 H2(g)    **Stresses**  **1** Addition of heat  **2** Addition of neon while a constant volume is maintained  **3**  Addition of hydrogen  **4** Pressure increased by decreasing the volume |

146. Match each of the stresses identified above with the letter on the graph that indicates the time at which the stress was applied.

**Stress applied:** \_\_\_ \_\_\_ \_\_\_ \_\_\_

**Time: W X Y Z**

*(Record your four digit answer in the numeric response section.)*

*Use the following information to answer the next question.*

|  |
| --- |
| The equilibrium 2 NO2(g)  N2O4(g) is established when 0.734 mol of NO2(g) at 25°C is placed in a 2.00 L flask. |

147. The equilibrium concentration of N2O4(g) is 0.125 mol/L. The value of the equilibrium constant is \_\_\_\_\_\_\_\_\_\_\_.

*(Record your three digit answer in the numeric response section.)*

148. At a temperature of 300°C and a pressure of 40.5 MPa, 90.0 mol of H2(g) and 80.0 mol of N2(g) are injected into a reaction vessel. When equilibrium is established, 37.0 mol of NH3(g) are present. The number of moles of H2(g) present in this equilibrium mixture is \_\_\_\_\_\_\_\_mol.

*(Record your three digit answer in the numeric response section.)*

*Use the following information to answer the next question.*

|  |
| --- |
| The graphs below show the relative concentration of N2O4(g) and NO2(g) as various stresses are exerted on the equilibrium system N2O4(g) + energy  2 NO2(g).  (Note: The graphs are not drawn to scale.)    Stresses: **1** removing NO2(g) **3** adding heat  **2** cooling system **4** adding N2O4(g) |

149. Match each of the graphs with the appropriate stress.

Graph M \_\_\_\_\_\_\_\_\_\_\_ *(Record in the* ***first*** *column)*

Graph N \_\_\_\_\_\_\_\_\_\_\_ *(Record in the* ***second*** *column)*

Graph O \_\_\_\_\_\_\_\_\_\_\_ *(Record in the* ***third*** *column)*

Graph P \_\_\_\_\_\_\_\_\_\_\_ *(Record in the* ***fourth*** *column)*

*(Record your four digit answer in the numeric response section.)*

*Use the following information to answer the next question.*

|  |
| --- |
| Sulfur dioxide gas reacts with oxygen to form sulfur trioxide gas, as represented by the equation  2 SO2(g) + O2(g)  2 SO3(g) ∆H = −197.8 kJ |

150. In order to obtain the equilibrium system above, 2.60 mol of SO2(g) and 2.30 mol of O2(g) are injected into a 1.00 L container. When the system reaches equilibrium, the concentration of the remaining SO2(g) is 1.32 mol/L. The concentration of O2(g) at equilibrium is \_\_\_\_\_\_\_\_ mol/L.

*(Record your three digit answer in the numeric response section.)*

*Use the following information to answer the next question.*

|  |  |  |  |
| --- | --- | --- | --- |
| Solution | Indicator Colour | | |
| phenolphthalein | indigo carmine | methyl orange |
| 1 | colourless | blue | red |
| 2 | pink | yellow | yellow |
| 3 | colourless | blue | yellow |
| 4 | pink | blue | yellow |

151. When the numbers corresponding to these solutions are arranged from **highest to lowest** pH value, their numerical sequence is \_\_, \_\_, \_\_, \_\_.

*(Record your four digit answer in the numeric response section.)*

*Use the following information to answer the next question.*

|  |
| --- |
| HSO4−(aq) + HCOO−(aq)  HCOOH(aq) + SO42−(aq)  **1 2 3 4** |

152. For the favoured reaction, the acid and its conjugate base and then the base and its conjugate acid, listed in that order are \_\_, \_\_, \_\_, \_\_.

*(Record your four digit answer in the numeric response section.)*

*Use the following information to answer the next question.*

|  |
| --- |
| **1** 0.10 mol/L H2S(aq)  **2** 0.10 mol/L NaOH(aq)  **3** 0.10 mol/L H2SO4(aq)  **4** 0.10 mol/L HOOCCOOH(aq) |

153. When the solutions are listed in order of increasing pH, the order is \_\_, \_\_, \_\_, \_\_.

*(Record your four digit answer in the numeric response section.)*

154. If hydrochloric acid is continuously added to a solution that contains both Na2CO3(aq) and Na2SO3(aq), the following reactions will occur:

**1**. H3O+(aq) + SO32−(aq)  HSO3−(aq) + H2O(l)

**2**. H3O+(aq) + CO32−(aq)  HCO3−(aq) + H2O(l)

**3**. H3O+(aq) + HSO3−(aq)  H2SO3(aq) + H2O(l)

**4**. H3O+(aq) + HCO3−(aq)  H2CO3(aq) + H2O(l)

The order in which these reactions occur is \_\_, \_\_, \_\_, \_\_.

*(Record your four digit response in the numeric response section.)*

*Use the following information to answer to answer the next \_ questions.*

|  |
| --- |
| Vinegar, an aqueous solution of acetic acid, is used to preserve and flavour food. Most of the vinegar used for this purpose has an acetic acid concentration of 0.83 mol/L. |

155. The pH of the vinegar is \_\_\_\_\_\_\_\_\_\_.

*(Record your three digit answer in the numeric response section.)*

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| Solutions of carbolic acid, commonly known as phenol (HC6H5O(aq)), are widely used as disinfectants. One such solution has a concentration of 6.44 x 10−2 mol/L and a pH of 5.60. Carbolic acid dissociates in water according to the equation  HC6H5O(aq) + H2O(l)  C6H5O-(aq) + H3O+(aq) |

156. In the *CRC Handbook of Chemistry and Physics*, the Ka for carbolic acid at 20.0°C is 1.3 x 10-10. The pOH of a 0.10 mol/L NaC6H5O(aq) at 20.0°C is \_\_\_\_\_\_\_\_\_\_.

*(Record your three digit answer in the numeric response section.)*

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| Methanoic (formic) acid is the irritant secreted during an ant bite. The irritation is partially due to the ionization of methanoic acid. The equilibrium equation for the ionization can be represented as  HCOOH(aq) + H2O(l)  H3O+(aq) + HCOO−(aq) |

157. The pH of a 0.10 mol/L NaHCOO(aq) is \_\_\_\_\_\_\_\_,

*(Record your three digit answer in the numeric response section.)*

*Use the following information to answer the next question.*

|  |
| --- |
| A student was asked to rank the relative strength of the following four acids.  **1** Formic acid (HCOOH(aq))  **2** Hydrazoic acid (HN3(aq))  **3** Hypobromous acid (HOBr(aq))  **4** Nitrous acid (HNO2(aq))  The student was given the following information.  HNO2(aq) + HCOO−(aq)  NO2−(aq) + HCOOH(aq) **< 50%**  HN3(aq) + OBr−(aq) N3−(aq) + HOBr(aq) **> 50%**  HN3(aq) + HCOO−(aq) N3−(aq) + HCOOH(aq) **< 50%** |

158. Based on the reaction evidence, the four acids, ranked from strongest to weakest, are \_\_, \_\_, \_\_, \_\_.

*(Record your four digit answer in the numeric response section.)*

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| Sodium hydrogen carbonate, NaHCO3(s) (baking soda) is used in baking. When lactic acid, HC3H5O3(aq), and baking soda are present, they cause dough’s and batters to rise. Lactic acid, a component of buttermilk, has a Ka = 1.4 x 10−4. |

159. The pH of 0.20 mol/L HC3H5O3(aq) is \_\_\_\_\_\_\_\_\_\_.

*(Record your three digit answer in the numeric response section.)*

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| The disagreeable odour of rancid butter is caused in part by the presence of butanoic acid (C3H7COOH(aq)). The Ka vale for C3H7COOH(aq) at 25°C is 1.5 x 10−5. |

160. The pH of a 0.10 mol.L C3H7COOH(aq) solution is \_\_\_\_\_\_\_\_.

*(Record your three digit answer in the numeric response section.)*

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| Body hair can be removed by using a chemical hair removal cream. One form of the cream contains sodium sulfide, calcium sulfide, and strontium sulfide. The sulfide ions in the cream will react with water, as represented by the following equation.  **Hair Removal Reaction**  S2−(aq) + H2O(l)  HS−(aq) + OH−(aq)  The solution resulting from the reaction will break some of the bonds in the hair, which allows the hair to be washed away. |

161. If the hydronium ion concentration of a sulfide ion solution is 1.1 x 10−13 mol/L, then the pOH is \_\_\_\_\_\_\_\_.

*(Record your three digit answer in the numeric response section.)*

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| Sulfur dioxide gas can be collected and used in the manufacturing of sulfuric acid. The equation that represents the manufacturing of sulfuric acid is represented below.  2 SO2(g) + O2(g) + 2 H2O(l)  2 H2SO4(aq) |

162. If the concentration of H3O+(aq) in a sulfuric acid solution is 1.2 x 10-5 mol/L, then the pOH of this solution is \_\_\_\_\_\_\_\_\_. *(Record your three digit answer in the numeric response section.)*

*Use the following information to answer the next question.*

|  |
| --- |
| A 0.500 mol/L solution of hydrazine (N2H4(aq)) contains the following equilibrium concentrations.  [N2H4(aq)] = 0.498 mol/L  [OH-(aq)] = 2.14 x 10−3 mol/L  [N2H5+(aq)] = 2.14 x 10−3 mol/L |

163. The Kb for hydrazine, in scientific notation, is ***a.bc***x 10***-d***. The values of ***a, b, c,*** and ***d*** are, repectively, \_\_\_, \_\_\_, \_\_\_, and \_\_\_.

*Use the following information to answer the next question.*

|  |
| --- |
| When equally concentrated solutions of HNO3(aq), CH3COOH(aq), HOOCCOOH(aq), and Na2S(aq) were titrated with either a strong acid or strong base the following titration curves were obtained. |

164. Match each of the graphs, as numbered above, with the corresponding titration species listed below.

HNO3(aq) \_\_\_\_\_\_\_\_\_\_\_ *(Record in the* ***first*** *column)*

CH3COOH(aq) \_\_\_\_\_\_\_\_\_\_\_ *(Record in the* ***second*** *column)*

HOOCCOOH(aq) \_\_\_\_\_\_\_\_\_\_\_ *(Record in the* ***third*** *column)*

Na2S(aq) \_\_\_\_\_\_\_\_\_\_\_ *(Record in the* ***fourth*** *column)*

*(Record your four digit answer in the numeric response section.)*

*Use the following information to answer the next question.*

|  |
| --- |
| **0.10 mol/L Solutions**  **1** NaNO2(aq) **3** HNO3(aq)  **2**  NaHCO3(aq)  **4**  Ba(OH)2(aq) |

165. When the solutions above are ordered from most basic to least basic, the order is \_\_, \_\_, \_\_, and \_\_.

*(Record your four digit answer in the numeric response section.)*

166. The concentration of H3O+(aq) ions in a particular bottle of wine is 3.2 x 10-4 mol/L. The pH of this wine is \_\_\_\_\_\_\_\_\_\_.

*(Record your three digit answer in the numeric response section.)*

*Use the following information to answer the next 3 questions.*

|  |
| --- |
| Coal and natural gas contain trace amounts of sulfur compound, which when burned, may lead to acid rain pollution.  **Reactions Related to Acid Rain**  **I** 2 H2S(g) + 3 O2(g)  2 H2O(g) + 2 SO2(g)  **II** 2 SO2(g) + O2(g)  2 SO3(g)  **III** SO2(g) +H2O(l)  H2SO3(aq)  **IV** SO3(g) + H2O(l)  H2SO4(aq) |

167. If the pH of a sample of rainwater is 3.2, then the pOH is \_\_\_\_\_\_\_.

*(Record your three digit answer in the numeric response section.)*

*Use the following information to answer the next question.*

|  |
| --- |
| **Equilibrium Reactions at 25°C**  **I**  CO2(g) + H2(g)  CO(g) + H2O(g) Kc = 0.137  **II**  CO(g) + H2O(g)  CO2(g) + H2(g) Kc = unknown |

168. Match each acid or base in the forward reaction, as numbered above, with the corresponding term given below.

acid \_\_\_\_\_\_\_\_\_ *(Record in the* ***first*** *column)*

conjugate base \_\_\_\_\_\_\_\_\_ *(Record in the* ***second*** *column)*

base \_\_\_\_\_\_\_\_\_ *(Record in the* ***third*** *column)*

conjugate acid \_\_\_\_\_\_\_\_\_ *(Record in the* ***fourth*** *column)*

*(Record your three digit answer in the numeric response section.)*

*Use the following information to answer the next question.*

|  |
| --- |
| **Chemical Species**  **1** HA3−(aq)  **2** H3A−(aq)  **3** H2A2−(aq)  **4** H4A(aq) |

169. As a solution of NaOH(aq) is continuously added to the acid H4A(aq), a sequence of quantitative reactions occurs. The order in which the species listed above would react is \_\_\_, \_\_\_, \_\_\_, and \_\_\_.

*(Record your four digit answer in the numeric response section.)*

*Use the following information to answer the next \_ questions.*

|  |
| --- |
| Anthocyanins (represented as A+(aq)) are responsible for the red colour of wine. Anthocyanins react with water as follows  2 H2O(l) + A+(aq)  H3O+(aq) + AOH(aq)  The AOH(aq) form is colourless. In a particular white wine sample, the equilibrium [H3O+(aq)] is 8.5 x 10-4 mol/L. |

170. The pH of the white wine sample at equilibrium is \_\_\_\_\_\_\_\_\_.

*(Record your three digit answer in the numeric response section.)*

*Use the following information to answer the next question.*

|  |
| --- |
| **Hypothetical Reactions**  **1** H4X(aq) + CO32−(aq)  H3X−(aq) + HCO3−(aq)  **2** HX3-(aq) + CO32−(aq)  X4−(aq) + HCO3−(aq)  **3**  H2X2-(aq) + CO32−(aq)  HX3−(aq) + HCO3−(aq)  **4** H3X-(aq) + CO32−(aq)  H2X2−(aq) + HCO3−(aq) |

171. The order of these reactions, beginning with the one that forms the most product to the one that forms the least product, is \_\_\_, \_\_\_, \_\_\_, and \_\_\_.

*(Record your four digit answer in the numeric response section.)*

**Short Answer**

*Use the following information to answer the next question.*

|  |
| --- |
| The unique flavour of fruits and berries is due to the presence of esters, chemical compounds that are easily synthesized in the laboratory. For example, ethyl propanoate is responsible for the flavour characteristic to pineapple. It is produced by the reaction  C2H5OH(l) + C2H5COOH(l)  C2H5COOC2H5(l) + H2O(l)  When 7.71 mol of C2H5OH(l) and 7.37 mol of C2H5COOH(l) are reacted in a beaker, 4.80 mol of C2H5COOC2H5(l) are present when equilibrium is established and the total volume of liquid is exactly 1.00 L. |

172. Calculate the Kc for this system. Are the reactants or products favoured at equilibrium? Justify your choice.

173. Identify a stress that would shift the following equilibrium system to favour the products.

2 NO2(g)  N2O4(g) + 101.4 kJ

brown colourless

Your response should include

• an explanation, based on Le Châtelier’s principle, of how the stress would

shift this equilibrium

• a procedure that would demonstrate the effect of applying the stress

• a prediction of what evidence there would be that the shift had occurred

174. *Use the following information to answer the next question.*

A chemist performed three trials of an experiment involving a closed system at equilibrium at 700 K. The system can be represented by the equation

H2(g) + I2(g)  2 HI(g) ∆H = −6.70 kJ

The chemist recorded the equilibrium concentrations of each gas in the table shown below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Trial** | **Equilibrium Concentration** | | |
| H2(g) mol/L | I2(g) mol/L | HI(g) mol/L |
| **1** | 0.165 | 0.0978 | 0.945 |
| **2** | 0.103 | 0.179 | 1.013 |
| **3** | unknown | unknown | 1.55 |

1a. Provide the equilibrium constant expression for the formation of HI(g). *(1 mark)*

1b. Use the information from trials 1 and 2 to calculate an average value for the equilibrium constant, Keq, for the formation of HI(g). *(3 marks)*

1c. In trial 3, the equilibrium was established by allowing a sample of HI(g) to decompose. Calculate the equilibrium concentration of H2(g) and I2(g) for trial 3. *(2 marks)*

1d. Identify a stress that would increase the value of the equilibrium constant, and **explain** how the stress is responsible for the increase. *(2 marks)*

175. *Use the following information to answer the next question.*

|  |
| --- |
| The formation of a pollutant gas, nitrogen monoxide (NO(g)), by the endothermic reaction of nitrogen with oxygen in a gasoline engine can be affected by changing the combustion termperature within the engine. The equilibrium constant for the production of one mole of NO(g) at 25°C is 1.0 x 10-17. |

Explain how an increase in temperature could affect the concentration of the pollutant gas and the value of the equilibrium constant.

Your response should also include

• relevant chemical equation(s)

• the relevant equilibrium constant expression(s)

• a description of a way that car manufacturers could reduce the NO(g) emissions in new model vehicles

176. The Haber-Bosch process for the industrial production of ammonia involves the equilibrium

N2(g) + 3 H2(g)  2 NH3(g) + 92.2 kJ

In a laboratory experiment designed to study this equilibrium, a chemical engineer injects 0.20 mol of N2(g) and 0.60 mol of H2(g) into a 1.0 L flask at 500°C. She records her analysis of the contents of the flask at 5 s intervals in the table shown.

|  |  |  |  |
| --- | --- | --- | --- |
| **Time (s)** | **Concentration (mol/L)** | | |
| **N2(g)** | **H2(g)** | **NH3(g)** |
| 0 | 0.20 | 0.60 | 0.00 |
| 5 | 0.14 | 0.42 | 0.12 |
| 10 | 0.11 | 0.33 | 0.18 |
| 15 | 0.10 | 0.30 | 0.20 |
| 20 | 0.10 | 0.30 | 0.20 |
| 25 | 0.10 | 0.30 | 0.20 |

Analyze the data. Your response should include

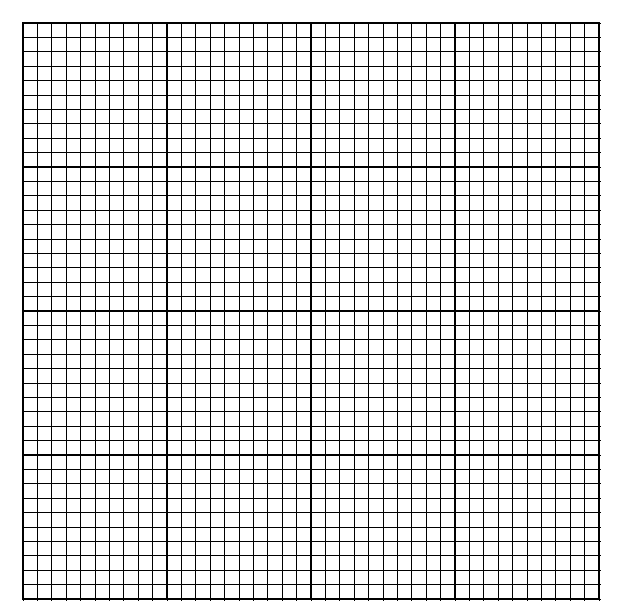
• a plot of the concentrations of N2(g), H2(g), and NH3(g) versus time on the grid provided, including an appropriate title *(3 marks)*

• the time required to establish equilibrium *(1 mark)*

• the equilibrium constant for the reaction *(2 marks)*

• two methods, other than increasing the amounts of reactants, that could increase the yield of ammonia *(2 marks)*

Communication *(2 marks)*



**Acid Base Equilibrium Answer Section**

**MULTIPLE CHOICE**

1. ANS: C PTS: 1 REF: June 1997 Diploma

OBJ: 30-D1.4k TOP: equilibrium KEY: expression

2. ANS: B PTS: 1 REF: June1997 Diploma

OBJ: 30-D1.1k TOP: equilibrium KEY: definition

3. ANS: D PTS: 1 REF: June 1997 Diploma

OBJ: 30-D1.2k TOP: equilibrium KEY: concentrations

4. ANS: D PTS: 1 REF: June 1997 Diploma

OBJ: 30-D1.3k TOP: equilibrium KEY: catalyst

5. ANS: B PTS: 1 REF: June 1997 Diploma

OBJ: 30-D1.3k TOP: equilibrium KEY: shifts

6. ANS: D PTS: 1 REF: June 1998 Diploma

OBJ: 30-D1.1k TOP: equilibrium KEY: definition

7. ANS: A PTS: 1 REF: June 1998 Diploma

OBJ: 30-D1.4k TOP: equilibrium expression KEY: equation from expression

8. ANS: C PTS: 1 REF: June 1998 Diploma

OBJ: 30-D1.3k TOP: tooth decay KEY: Le Chatelier's

9. ANS: A PTS: 1 REF: June 1998 Diploma

OBJ: 30-D2.3k TOP: equilibrium constant KEY: constant for the reverse equation

10. ANS: B PTS: 1 REF: June 1991 Diploma

OBJ: 30-D1.3k TOP: Le Chatelier KEY: indicator and colour change

11. ANS: D PTS: 1 REF: June 2000 Diploma

OBJ: 30-D1.1k TOP: equilibrium KEY: rates of reaction

12. ANS: B PTS: 1 REF: June 2000 Diploma

OBJ: 30-D2.3k TOP: equilibrium calculation

KEY: given Keq and equilibrium concentrations

13. ANS: A PTS: 1 REF: 2003 Released Items

OBJ: 30-D1.3k TOP: Le Chatelier KEY: shifts and effect on Keq

14. ANS: C PTS: 1 REF: 2004 Released Items

OBJ: 30-D1.1k TOP: equilibrium KEY: rates of reaction

15. ANS: D PTS: 1 REF: 2006 Released Items

OBJ: 30-D1.3k TOP: Le Chatelier KEY: concentration change with a shift left

16. ANS: D PTS: 1 REF: January 2002 Diploma

OBJ: 30-D1.3k TOP: equilibrium KEY: effect of a catalyst

17. ANS: D PTS: 1 REF: January 2002 Diploma

OBJ: 30-D1.3k TOP: equilibrium KEY: shift and exo/endothermic

18. ANS: C PTS: 1 REF: June 2001 Diploma

OBJ: 30-D1.3k TOP: equilibrium KEY: predicting a shift

19. ANS: D PTS: 1 REF: June 2001 Diploma

OBJ: 30-D1.5k TOP: weak base equilibrium KEY: identification of acids

20. ANS: B PTS: 1 REF: June 2001 Diploma

OBJ: 30-D1.7k TOP: weak base equilibrium KEY: identify an amphiprotic species

21. ANS: A PTS: 1 REF: June 2001 Diploma

OBJ: 30-D1.8k TOP: weak base equilibrium KEY: identification of a buffer

22. ANS: A PTS: 1 REF: June 2001 Diploma

OBJ: 30-D1.1k TOP: equilibrium KEY: closed system

23. ANS: D PTS: 1 REF: June 2001 Diploma

OBJ: 30-D1.4k TOP: equilibrium concentrations

KEY: amount of products from value of Keq

24. ANS: D PTS: 1 REF: June 2001 Diploma

OBJ: 30-D1.4k TOP: equilibrium KEY: constant expression given the equation

25. ANS: D PTS: 1 REF: June 2001 Diploma

OBJ: 30-D2.3k TOP: equilibrium KEY: concentration of a product given Keq and [initial]

26. ANS: C PTS: 1 REF: June 2001 Diploma

OBJ: 30-D1.3k TOP: equilibrium KEY: predicting a shift

27. ANS: D PTS: 1 REF: January 2001 Diploma

OBJ: 30-D1.4k TOP: equilbrium constant expression KEY: given equation

28. ANS: B PTS: 1 REF: January 2001 Diploma

OBJ: 30-D2.3k TOP: equilibrium calculations

KEY: concentration of a reactant at equilibrium

29. ANS: D PTS: 1 REF: January 2001 Diploma

OBJ: 30-D1.3k TOP: equilibrium constant KEY: predicting a shift

30. ANS: B PTS: 1 REF: June 1998 Diploma

OBJ: 30-D2.1k TOP: pH KEY: indicator colour

31. ANS: D PTS: 1 REF: June 1998 Diploma

OBJ: 30-D1.6k TOP: neutralization reaction KEY: identifying a weak base

32. ANS: A PTS: 1 REF: June 1998 Diploma

OBJ: 30-D1.8k TOP: acids KEY: buffering

33. ANS: C PTS: 1 REF: June 1998 Diploma

OBJ: 30D-1.6k LOC: weak acid TOP: Bronsted Lowry equation

34. ANS: B PTS: 1 REF: January 2002 Diploma

OBJ: 30-D1.6k TOP: acid KEY: identify a base

35. ANS: C PTS: 1 OBJ: 30-D2.1k TOP: hydronium ion concentration

KEY: calculation of pH and pOH

36. ANS: C PTS: 1 REF: January 2001 Diploma

OBJ: 30-D2.2k TOP: acid solutions KEY: lowest pH

37. ANS: D PTS: 1 REF: January 2001 Diploma

OBJ: 30-D2.1sts TOP: acid rain KEY: ecological perspective

38. ANS: A PTS: 1 REF: January 2001 Diploma

OBJ: 30-D2.1sts TOP: [carbon dioxide] KEY: reactions that produce

39. ANS: D PTS: 1 REF: June 1999 Diploma

OBJ: 30-D1.8k TOP: reaction KEY: creation of a buffer

40. ANS: B PTS: 1 REF: June 1999 Diploma

OBJ: 30-D1.1k TOP: equilibrium KEY: definition

41. ANS: D PTS: 1 REF: June 1999 Diploma

OBJ: 30-D1.3k TOP: equilibrium KEY: predicting a shift

42. ANS: B PTS: 1 REF: January 1999 Diploma

OBJ: 30-D1.1k TOP: equilibrium KEY: characteristics of a system in equilibrium

43. ANS: D PTS: 1 REF: January 1999 Diploma

OBJ: 30-D1.4k TOP: equilibrium KEY: constant expression

44. ANS: B PTS: 1 REF: January 1999 Diploma

OBJ: 30-D2.3k TOP: equilibrium KEY: concentrations at equilibrium

45. ANS: D PTS: 1 REF: January 1999 Diploma

OBJ: 30-D1.2k TOP: equilibrium KEY: predicting shifts

46. ANS: C PTS: 1 REF: January 1998 Diploma

OBJ: 30-D1.3k

47. ANS: A PTS: 1 REF: January 1998 Diploma

OBJ: 30-D1.4k

48. ANS: B PTS: 1 OBJ: 30-D1.3k

49. ANS: D PTS: 1 OBJ: 30-D2.3k

50. ANS: B PTS: 1 REF: January 1998 Diploma

OBJ: 30-D1.3s

51. ANS: B PTS: 1 REF: 2005 Released items

OBJ: 30-D1.3s TOP: equilibrium KEY: determining from a graph

52. ANS: C PTS: 1 REF: 2005 Released items

OBJ: 30-D1.3k TOP: Le Chatelier KEY: shift right

53. ANS: B PTS: 1 REF: 2005 Released items

OBJ: 30-D1.2k TOP: equilibrium equation KEY: writing

54. ANS: A PTS: 1 REF: 2005 Released items

OBJ: 30-D1.3k TOP: Keq and [ ] KEY: changes when reactant added

55. ANS: D PTS: 1 REF: 2005 Released items

OBJ: 30-D2.3k TOP: Keq KEY: reverse reaction

56. ANS: C PTS: 1 REF: 2005 Released items

OBJ: 30-D1.3k TOP: equilibrium concentration KEY: given Keq

57. ANS: C PTS: 1 REF: June 1997 Diploma

OBJ: 30-D2.2k TOP: acid base KEY: weak acid pH

58. ANS: D PTS: 1 REF: June 1997 Diploma

OBJ: 30-D1.9k TOP: acid base KEY: titration curves

59. ANS: A PTS: 1 REF: June 1997 Diploma

OBJ: 30-D2.1k TOP: acids KEY: pH comparison

60. ANS: A PTS: 1 REF: June 1997 Diploma

OBJ: 30-D1.9k TOP: acids KEY: phosphoric acid titration curve

61. ANS: B PTS: 1 REF: June 1997 Diploma

OBJ: 30-D1.9k TOP: acid base KEY: indicator selection on pH curve

62. ANS: C PTS: 1 REF: June 1997 Diploma

OBJ: 30-D2.1k KEY: acid base MSC: indicator colour and pH

63. ANS: B PTS: 1 REF: June 1997 Diploma

OBJ: 30-D1.7k TOP: acid base KEY: amphoteric definition

64. ANS: A PTS: 1 REF: June 1997 Diploma

OBJ: 30-D1.8k TOP: acid base KEY: buffers

65. ANS: D PTS: 1 REF: June 1997 Diploma

OBJ: 30-D1.8k TOP: acid base KEY: buffers

66. ANS: A PTS: 1 REF: June 1998 Diploma

OBJ: 30-D2.2k TOP: equilibrium constants KEY: Ka and acid strength

67. ANS: A PTS: 1 REF: June 1998 Diploma

OBJ: 30-D1.9k TOP: titration curve KEY: weak acid titration curve

68. ANS: B PTS: 1 REF: June 1998 Diploma

OBJ: 30-D1.9k TOP: titration curve KEY: indicator selection

69. ANS: A PTS: 1 REF: June 1998 Diploma

OBJ: 30-D1.9k TOP: pH curve KEY: predicting reactants from shape

70. ANS: C PTS: 1 REF: June 1998 Diploma

OBJ: 30-D1.7k TOP: acid KEY: identification of a polyprotic acid

71. ANS: D PTS: 1 REF: June 1991 Diploma

OBJ: 30-D1.6k TOP: acid-base equilbrium

KEY: identifying acid, base, position of equilibrium

72. ANS: A PTS: 1 REF: June 1991 Diploma

OBJ: 30-D2.2k TOP: weak acid equilibrium KEY: species present

73. ANS: D PTS: 1 REF: January 1990 Diploma

OBJ: 30-D2.2k TOP: weak acid KEY: calculation of [H30+]

74. ANS: C PTS: 1 REF: January 1990 Diploma

OBJ: 30-D1.6k TOP: acid base reactions

KEY: predicting most likely reaction from the table

75. ANS: D PTS: 1 REF: January 1990 Diploma

OBJ: 30-D1.6k TOP: predicting reactions KEY: position of the equilibrium

76. ANS: A PTS: 1 REF: January 2000 Diploma

OBJ: 30-D2.3k TOP: weak acid KEY: concentration at equilbrium

77. ANS: B PTS: 1 REF: January 2000 Diploma

OBJ: 30-D2.2k TOP: weak acid KEY: calculation of equilibrium concentrations

78. ANS: D PTS: 1 REF: January 2000 Diploma

OBJ: 30-D1.6k TOP: Bronsted-Lowry reactions KEY: predicting net ionic equations

79. ANS: B PTS: 1 REF: January 2000 Diploma

OBJ: 30-D1.7k TOP: Bronsted-Lowry equations KEY: conjugate acid-base pair

80. ANS: A PTS: 1 REF: January 2000 Diploma

OBJ: 30-D1.7k TOP: Bronsted-Lowry equation KEY: amphiprotic species

81. ANS: C PTS: 1 REF: January 2000 Diploma

OBJ: 30-D1.4k TOP: weak acid equilibrium KEY: Ka expression

82. ANS: B PTS: 1 REF: January 2000 Diploma

OBJ: 30-D2.3k TOP: weak acid equilibrium

KEY: calculating Ka given initial conc and pH

83. ANS: C PTS: 1 REF: January 2000 Diploma

OBJ: 30-D2.2k TOP: weak acid Ka KEY: calculation of Kb

84. ANS: D PTS: 1 REF: January 2000 Diploma

OBJ: 30-D1.6k TOP: weak acid KEY: predicting the BL reaction

85. ANS: A PTS: 1 REF: January 2000 Diploma

OBJ: 30-D1.9k TOP: titration curve KEY: identifying a suitable indicator

86. ANS: B PTS: 1 REF: January 2000 Diploma

OBJ: 30-D1.8k TOP: buffers KEY: predicting a reaction when an acid is added to a buffer

87. ANS: A PTS: 1 REF: January 2000 Diploma

OBJ: 30-D2.1k TOP: weak acids KEY: [hydronium ion] from pH

88. ANS: B PTS: 1 REF: January 2000 Diploma

OBJ: 30-D1.3k TOP: Le Chatelier KEY: predicting a shift

89. ANS: D PTS: 1 REF: June 2000 Diploma

OBJ: 30-D1.8k TOP: blood buffer KEY: definition

90. ANS: B PTS: 1 REF: June 2000 Diploma

OBJ: 30-D1.8k TOP: blood buffers KEY: identity of buffer

91. ANS: B PTS: 1 REF: June 2000 Diploma

OBJ: 30-D1.7k TOP: weak acid KEY: identify amphiprotic species

92. ANS: C PTS: 1 REF: June 2000 Diploma

OBJ: 30-D1.6k TOP: weak acid equilibrium KEY: concentration of species

93. ANS: C PTS: 1 REF: June 2000 Diploma

OBJ: 30-D2.2k TOP: weak base KEY: calculation of [OH-]

94. ANS: A PTS: 1 REF: June 2000 Diploma

OBJ: 30-D1.3k TOP: weak acid equilibrium KEY: catalyst and Keq

95. ANS: C PTS: 1 REF: June 2000 Diploma

OBJ: 30-D1.9k TOP: WA titration curve KEY: equivalence point

96. ANS: A PTS: 1 REF: June 2000 Diploma

OBJ: 30-D1.9k TOP: WA titration curve KEY: buffering region

97. ANS: B PTS: 1 REF: June 2000 Diploma

OBJ: 30-D1.9k TOP: WA titration curve KEY: indicator selection

98. ANS: D PTS: 1 REF: June 2000 Diploma

OBJ: 30-D1.6k TOP: weak acid KEY: predicting a reaction using the table

99. ANS: B PTS: 1 REF: June 2000 Diploma

OBJ: 30-D2.3k TOP: weak acid equilibrium

KEY: calculation of [hydronium] given Ka and [initial]

100. ANS: D PTS: 1 REF: 2003 Released Items

OBJ: 30-D1.6k TOP: acid base equations KEY: predicting from the table

101. ANS: C PTS: 1 REF: 2003 Released Items

OBJ: 30-D2.2k TOP: weak base KEY: [hydroxide] from pH

102. ANS: A PTS: 1 REF: 2003 Released Items

OBJ: 30-D2.3k TOP: weak acid equilibrium

KEY: calculation of hydronium ion concentration

103. ANS: D PTS: 1 REF: 2003 Released Items

OBJ: 30-D1.7k TOP: weak acid KEY: conjugate base

104. ANS: B PTS: 1 REF: 2004 Released Items

OBJ: 30-D2.3k TOP: weak acid equilibrium KEY: concentration at equilibrium

105. ANS: B PTS: 1 REF: 2004 Released Items

OBJ: 30-D1.9k TOP: weak acid KEY: pH curve

106. ANS: C PTS: 1 REF: 2004 Released Items

OBJ: 30-D1.8k TOP: weak acid titration KEY: buffer formation

107. ANS: D PTS: 1 REF: 2004 Released Items

OBJ: 30-D1.7k TOP: weak acid KEY: polyprotic and amphiprotic species

108. ANS: C PTS: 1 REF: 2004 Released Items

OBJ: 30-D2.2k TOP: weak base KEY: Kb calculation

109. ANS: D PTS: 1 REF: 2006 Released Items

OBJ: 30-D1.5k TOP: acid base reactions KEY: identifying BL acids and bases

110. ANS: D PTS: 1 REF: 2006 Released Items

OBJ: 30-D2.2k TOP: equilbrium constants KEY: values of a polyprotic species

111. ANS: C PTS: 1 REF: 2007 Released Items

OBJ: 30-D2.1k TOP: weak acid KEY: pH/pOH change

112. ANS: B PTS: 1 REF: January 2002 Diploma

OBJ: 30-D1.9k TOP: titration curve KEY: buffering

113. ANS: D PTS: 1 REF: January 2002 Diploma

OBJ: 30-D1.8k TOP: buffer KEY: identify a buffer from a number of solutions

114. ANS: C PTS: 1 REF: January 2002 Diploma

OBJ: 30-D1.6k TOP: acids KEY: strength of acid and Ka

115. ANS: B PTS: 1 REF: January 2002 Diploma

OBJ: 30-D1.9k TOP: pH curve KEY: SB and WA

116. ANS: B PTS: 1 REF: January 2002 Diploma

OBJ: 30-D1.9k TOP: pH curve KEY: equivalence point determination

117. ANS: A PTS: 1 REF: January 2002 Diploma

OBJ: 30-D1.9k TOP: pH curve KEY: indicator selection

118. ANS: D PTS: 1 REF: January 2002 Diploma

OBJ: 30-D1.4k TOP: equilibrium constant expression KEY: given chemical equilibrium

119. ANS: B PTS: 1 REF: January 2002 Diploma

OBJ: 30-D2.3k TOP: weak acid KEY: hydronium ion concentration

120. ANS: C PTS: 1 REF: June 2001 Diploma

OBJ: 30-D1.5k TOP: acid KEY: weak monoprotic acid

121. ANS: C PTS: 1 REF: June 2001 Diploma

OBJ: 30-D1.7k TOP: neutralization reaction KEY: conjugate acid-base pair

122. ANS: C PTS: 1 REF: January 2001 Diploma

OBJ: 30-D1.9k TOP: titration curves KEY: identifying equivalence point

123. ANS: A PTS: 1 REF: January 2001 Diploma

OBJ: 30-D1.9k TOP: acid base curve KEY: identify the sample and titrant

124. ANS: A PTS: 1 REF: January 2001 Diploma

OBJ: 30-D2.2k TOP: [hydroxide ion] KEY: given pH

125. ANS: C PTS: 1 REF: January 2001 Diploma

OBJ: 30-D1.6k TOP: BL reactions KEY: products favoured

126. ANS: D PTS: 1 REF: January 2001 Diploma

OBJ: 30-D1.8k TOP: buffers KEY: identification of a buffer pair

127. ANS: A PTS: 1 REF: January 2001 Diploma

OBJ: 30-D1.6k, 30-D1.8k TOP: buffer KEY: reaction when acid is added

128. ANS: C PTS: 1 REF: June 1999 Diploma

OBJ: 30-D1.6k TOP: acid-base equilibrium KEY: position on the table

129. ANS: B PTS: 1 REF: June 1999 Diploma

OBJ: 30-D1.8k TOP: buffer KEY: shift in the equilbrium

130. ANS: D PTS: 1 REF: June 1999 Diploma

OBJ: 30-D1.6k TOP: buffer KEY: predict equation when acid is added

131. ANS: C PTS: 1 REF: January 1998 Diploma

OBJ: 30-D1.3k

132. ANS: B PTS: 1 REF: January 1999 Diploma

OBJ: 30-D1.6k TOP: BL reactions KEY: predicting from a table

133. ANS: D PTS: 1 REF: January 1999 Diploma

OBJ: 30-D1.9k TOP: titration curve KEY: indicator selection

134. ANS: D PTS: 1 REF: January 1998 Diploma

OBJ: 30-D1.7k

135. ANS: D PTS: 1 REF: January 1998 Diploma

OBJ: 30-D2.3k

136. ANS: C PTS: 1 REF: January 1996 Diploma

OBJ: 30-D2.3k

137. ANS: C PTS: 1 REF: 2005 Released items

OBJ: 30-D2.1k TOP: pH >14 KEY: strong base

138. ANS: D PTS: 1 REF: 2005 Released items

OBJ: 30-D2.2k TOP: pH KEY: based on Ka

139. ANS: C PTS: 1 REF: 2005 Released items

OBJ: 30-2.2k TOP: calculate Kb KEY: given Ka

140. ANS: C PTS: 1 REF: 2005 Released items

OBJ: 30-D1.5k TOP: equation KEY: identify acids

141. ANS: A PTS: 1 REF: 2005 Released items

OBJ: 30-D1.8k TOP: buffer KEY: equation to show addition of an acid

142. ANS: A PTS: 1 REF: 2005 Released items

OBJ: 30-B1.9k TOP: titration curve KEY: identifying acids

**NUMERIC RESPONSE**

143. ANS: 2.00 PTS: 1 REF: June 1997 Diploma OBJ: 30-D1.3s

TOP: equilibrium KEY: graphs

144. ANS: 1.33 PTS: 1 REF: June 1997 Diploma OBJ: 30-D1.3s

TOP: equilibrium KEY: constant calculation

145. ANS: 2.14 PTS: 1 REF: January 2002 Diploma OBJ: 30-D2.3k

TOP: equilibrium KEY: constant calculation

146. ANS: 3241 PTS: 1 REF: January 2002 Diploma OBJ: 30-D1.3s

TOP: equilibrium diagram KEY: identifying stresses on an equilibrium

147. ANS: 9.13 PTS: 1 REF: June 1999 Diploma OBJ: 30-D2.3k

TOP: equilibrium calculation KEY: calculating Keq

148. ANS: 34.5 PTS: 1 REF: January 1999 Diploma OBJ: 30-D2.3k

TOP: calculation KEY: ice table

149. ANS: 3142 PTS: 1 REF: January 1998 Diploma OBJ: 30-D1.3s

150. ANS: 1.66 PTS: 1 REF: 2005 Released items OBJ: 30-D2.3k

TOP: equilibrium concentrations KEY: given initial and one equilibrium concentrations

151. ANS: 2431 PTS: 1 REF: June 1992 Diploma OBJ: 30-D1.6k

TOP: acid base KEY: indicator colour and pH

152. ANS: 1423 PTS: 1 REF: June 1997 Diploma OBJ: 30-D1.7k

TOP: acid base KEY: identifying acids and bases

153. ANS: 3412 PTS: 1 REF: June 1991 Diploma OBJ: 30-D2.2k

TOP: acids and bases KEY: qualitatively ranking pH

154. ANS: 2143 PTS: 1 REF: June 1991 Diploma OBJ: 30-D1.6k

TOP: predicting reactions KEY: order of reaction for a series of bases

155. ANS: 2.41 PTS: 1 REF: January 2000 Diploma OBJ: 30-B2.2k

TOP: weak acid KEY: calculation of pH

156. ANS: 5.11 PTS: 1 REF: January 2000 Diploma OBJ: 30-D2.3k

TOP: Kb expression KEY: calculating a pOH given [initial] and Ka

157. ANS: 8.37 PTS: 1 REF: June 2000 OBJ: 30-D2.2k TOP: weak base

KEY: pH calculation

158. ANS: 4123 PTS: 1 REF: June 2000 Diploma OBJ: 30-D1.6k

TOP: weak acid strength KEY: rank WA based on % reaction

159. ANS: 2.28 PTS: 1 REF: June 2000 Diploma OBJ: 30-D2.2k

TOP: weak acid equilibrium KEY: calculation of pH given [initial] and Ka

160. ANS: 2.91 or 2.92 PTS: 1 REF: 2003 Released Items OBJ: 30-D2.2k

TOP: weak acid KEY: pH calculation

161. ANS: 1.04 PTS: 1 REF: 2006 Released Items OBJ: 30-D2.1k

TOP: pOH calculation KEY: given hydronium ion concentration

162. ANS: 9.08 PTS: 1 REF: 2007 Released Items OBJ: 30-D2.1k

TOP: pOH calculation KEY: given hydronium ion concentration

163. ANS: 9206 PTS: 1 REF: June 2001 Diploma OBJ: 30-D2.3k

TOP: weak base equilibrium KEY: Kb calculation given concentrations

164. ANS: 2413 PTS: 1 REF: June 2001 Diploma OBJ: 30-D1.9k

TOP: pH curves KEY: identifying species being titrated

165. ANS: 4213 PTS: 1 REF: January 2001 Diploma OBJ: 30-D2.1s

TOP: bases KEY: ranking basicity

166. ANS: 3.49 PTS: 1 REF: January 2001 Diploma OBJ: 30-D2.2k

TOP: pH calculation KEY: given [hydronium ion]

167. ANS: 10.8 PTS: 1 REF: January 2001 Diploma OBJ: 30-D2.2k

TOP: pOH KEY: given pH

168. ANS: 1423 PTS: 1 REF: June 1999 Diploma OBJ: 30-D1.7k

TOP: acid-base reaction KEY: identify acid and bases

169. ANS: 4231 PTS: 1 REF: June 1999 Diploma OBJ: 30-D1.6k

TOP: polyprotic acid KEY: sequence of reaction

170. ANS: 3.07 PTS: 1 REF: January 1998 Diploma OBJ: 30-D2.1k

171. ANS: 1432 PTS: 1 REF: January 1993 Diploma OBJ: 30-D1.6k

**SHORT ANSWER**

172. ANS:

2 marks for correct method for calculating Kc

1 mark for correct answer (3.10)

1 mark for stating that products are favoured

1 mark for stating that the value of Kc>1

PTS: 1 REF: June 1998 Diploma OBJ: 30-D2.3k, 30-D1.3k

TOP: equilibrium calculations KEY: system at equilibrium

173. ANS:

Key - a stress which would cause the equilibrium to shift right (2 marks)

Supports - an explanation (1 mark)

a procedure (1 mark)

a prediction of the colour change (1 mark)

PTS: 1 REF: January 2000 Diploma OBJ: 30-D1.3k, 30-D1.1s

TOP: Le Chateliers principle KEY: prediction, lab procedure

174. ANS: 1a. expression - 1 mark

1b. correct substitution - 1 mark

correct answer - 1 mark

average calculation - 1 mark

1c. correct method - 1 mark

correct answer - 1 mark

1d. cool it - 1 mark explanation - 1 mark

PTS: 1 REF: June 2004 Diploma OBJ: 30-D2.3s

TOP: equilibrium KEY: calculations, stresses

175. ANS: Key 2 marks - increase pollutant gas, decrease constant value + explanation

Support 1 mark - chemical equation

1 mark - equilibrium constant expression

1 mark - method to reduce

PTS: 1 REF: June 2001 Diploma OBJ: 30-1.3sts

TOP: equilibrium KEY: effect of temperature on Keq

176. ANS: Graph - 1 mark for appropriate title + labels

1 mark for accurate plotting

1 mark for line of best fit

Time 1 mark for clearly identifying 15 s

Constant 1 mark for correct method

1 mark for correct value

Methods 1 mark each method

PTS: 1 REF: January 1996 Diploma OBJ: 30-D1.2, 30-D2.3