2011

Chemistry 30

Unit 2 Equilibrium Focusing on Acids and Bases

Practice Exam

RTD
Diploma Preparation
1/1/2011

Sodium hydroxide and chlorine are commercially produced by the chloralkali process. If sodium hydroxide and chlorine gas are not separated from each other, then they will react to form sodium hypochlorite. In this reaction, chlorine is simultaneously reduced and oxidized (disproportionation).

Disproportionation of chlorine: $Cl_2 + 2NaOH \rightleftharpoons NaCl + NaClO + H_2O$

1. **Calculate the base ionization constant for hypochlorite**

   The K_a value for hypochloric acid is 3.5×10^{-8}

$K_{b\ ClO-}$ equals:

A. 3.5×10^{6}
B. 3.5×10^{-6}
C. 2.9×10^{-7}
D. 2.9×10^{7}

The concentration of sodium hypochlorite in household bleach can be determined by titration with a reducing agent such as iodide solution.

$OCl^-_{(aq)} + 2I^-_{(aq)} + 2H_3O^+_{(aq)} \rightarrow I_{2\,(aq)} + Cl^-_{(aq)} + 3H_2O_{(l)}$

The colour changes from colourless to brown, due to the formation of iodine.

2. **If a lab technician used 10 mL of 0.050 mol/L iodide solution to titrate 50 mL of hypochlorite, then what was the concentration of hypochlorite in the bleach sample?**

A. 0.3 mol/L
B. 0.02 mol/L
C. 0.001 mol/L
D. 0.005 mol/L

NR 1 Calculate the pH of a 0.015 mol/L sodium hypochlorite solution.

$OCl^-_{(aq)} + H_2O_{(l)} \rightleftharpoons OH^-_{(aq)} + HClO_{(aq)}$

(Record your answer to **three digits**.)

pH=________________

3. **Chemical systems reach equilibrium when**
   A. the number of moles of products equals the number of moles of reactants.
   B. no reaction is occurring.
   C. the rates of forward and reverse reactions become equal.
   D. the mass of products equals the mass of the reactants.

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

Nitrogen monoxide is a diatomic gas which is an important cell signaling molecule in mammals. Furthermore, nitrogen monoxide is an extremely important intermediate in the chemical industry. It is also an air pollutant produced by combustion in automobile engines and in fossil fuel power plants.
$N_{2\,(g)} + O_{2\,(g)} \rightleftharpoons 2NO_{(g)}$ $\Delta H = +182.7$ J

1. The amount of NO $_{(g)}$ at equilibrium can be increased by adding ______i_______ and increasing _____ii_____.

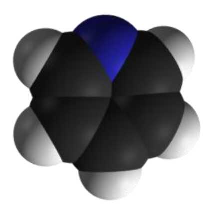
	i.	ii.
A.	Nitrogen monoxide	Temperature
B.	Nitrogen monoxide	Pressure
C.	Oxygen	Pressure
D.	Nitrogen	Temperature

5. A reaction in which equilibrium favours the products is

A. $HSO_4^-{}_{(aq)} + F^- \rightleftharpoons HF_{(aq)} + SO_4^{2-}{}_{(aq)}$
B. $HCN_{(aq)} + F^-{}_{(aq)} \rightleftharpoons HF_{(aq)} + CN^-{}_{(aq)}$
C. $HF_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+{}_{(aq)} + F^-{}_{(aq)}$
D. $HF_{(aq)} + SO_4^{2-}{}_{(aq)} \rightleftharpoons HSO_4^-{}_{(aq)} + F^-{}_{(aq)}$

6. Which of the following substances is most likely amphiprotic?

A. $C_2H_{4(aq)}$
B. $CH_3OH_{(aq)}$
C. $CH_3COO^-{}_{(aq)}$
D. $HOOCOO^-{}_{(aq)}$



Pyridine is a basic heterocyclic organic compound. Pyridine was discovered in 1849 by the Scottish chemist Thomas Anderson. He was able to isolate pure pyridine through fractional distillation of bone oil. It is a colorless, highly flammable, water-soluble liquid with a fish-like odour. Pyridine is used as a solvent and as a chemical reactant in organic synthesis.

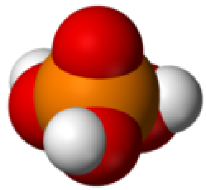
Pyridine, $C_5H_5N(l)$ is a weak base. The base ionization constant for pyridine is 1.8×10^{-9}.

7. The pH of a 0.20 mol/L aqueous solution of pyridine will be

A. 4.72
C. 12.11
B. 9.28
D. 7.7

The uses of phosphoric acid are not only limited to rust removal and soft drink acidification, but there are also medical applications. Phosphoric acid is used in dentistry and orthodontics as an etching solution, to clean or roughen the surfaces of teeth where dental fillings will be placed.

8. Phosphoric acid is a(n):



A. Strong acid
B. Amphiprotic substance
C. Diprotic acid
D. Triprotic acid

9. Which of the following expressions correctly represents each of the ionization steps which take place in an aqueous solution of phosphoric acid?

A. $K_{a1} = \frac{[H_3O^+][PO_4{}^{3-}]}{[HPO_4{}^{2-}]}$ $K_{a2} = \frac{[H_3O^+][HPO_4{}^{2-}]}{[H_2PO_4{}^-]}$ $K_{a3} = \frac{[H_3O^+][PO_4{}^{3-}]}{[HPO_4{}^-]}$

B. $K_{a1} = \frac{[H_3O^+][PO_4{}^{3-}]}{[HPO_4{}^{2-}]}$ $K_{a2} = \frac{[H_3O^+][PO_4{}^{3-}]}{[HPO_4{}^-]}$ $K_{a3} = \frac{[H_3O^+][HPO_4{}^{2-}]}{[H_2PO_4{}^-]}$

C. $K_{a1} = \frac{[H_3O^+][H_2PO_4{}^-]}{[H_3PO_4]}$ $K_{a2} = \frac{[H_3O^+][HPO_4{}^{2-}]}{[H_2PO_4{}^-]}$ $K_{a3} = \frac{[H_3O^+][PO_4{}^{3-}]}{[HPO_4{}^{2-}]}$

D. $K_{a1} = \frac{[H_3O^+][PO_4{}^{3-}]}{[HPO_4{}^-]}$ $K_{a2} = \frac{[H_3O^+][PO_4{}^{3-}]}{[HPO_4{}^{2-}]}$ $K_{a3} = \frac{[H_3O^+][HPO_4{}^{2-}]}{[H_2PO_4{}^-]}$

NR 2 Calculate the pH of a 0.02 mol/L benzoic acid solution

(Record your answer to **three digits**.)

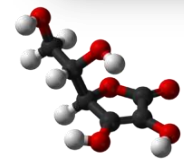
pH =______________

A buffer solution is an aqueous solution which consists of a mixture of a weak acid and its conjugate base or a weak base and its conjugate acid.

10. The function of chemical buffers in the blood is to:

A. Keep the blood pressure constant
B. Act as catalysts to increase the rate of reaction
C. Decrease the activation energy
D. Maintain a constant pH when a small amount of acid or base is added

Ascorbic acid is a weak acid with antioxidant properties. When pure, it is a white to light-yellow crystalline powder. Ascorbic acid is commonly known as vitamin C.



11. Which of the following pairs are the conjugate acid base pairs of the reaction of ascorbic acid with water?

A. $H_2C_6H_6O_{6(aq)}/H_3O^+_{(aq)}$ and $H_2O_{(l)}/ HC_6H_6O_6{}^-_{(aq)}$

B. $H_2C_6H_6O_{6(aq)}/H_2O_{(l)}$ and $H_3O^+_{(aq)}/ HC_6H_6O_6{}^-_{(aq)}$

C. $H_2C_6H_6O_{6(aq)}/ HC_6H_6O_6{}^-_{(aq)}$ and $H_2O_{(l)} /H_3O^+_{(aq)}$

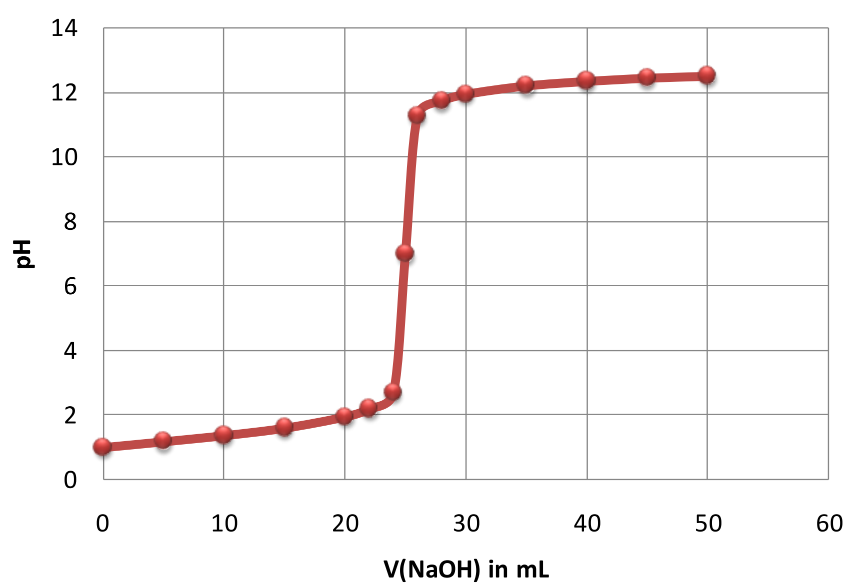
D. $HC_6H_6O_6{}^-_{(aq)}/H_3O^+_{(aq)}$ and $H_2C_6H_6O_{6(aq)}/H_2O_{(l)}$

NR 3 Calculate the pH of a 0.0015 mol/L ascorbic acid solution

(Record your answer to **three digits**.)

pH =______________

12. During a titration experiment, the following graph was recorded:



The graph plotted belongs to a titration between

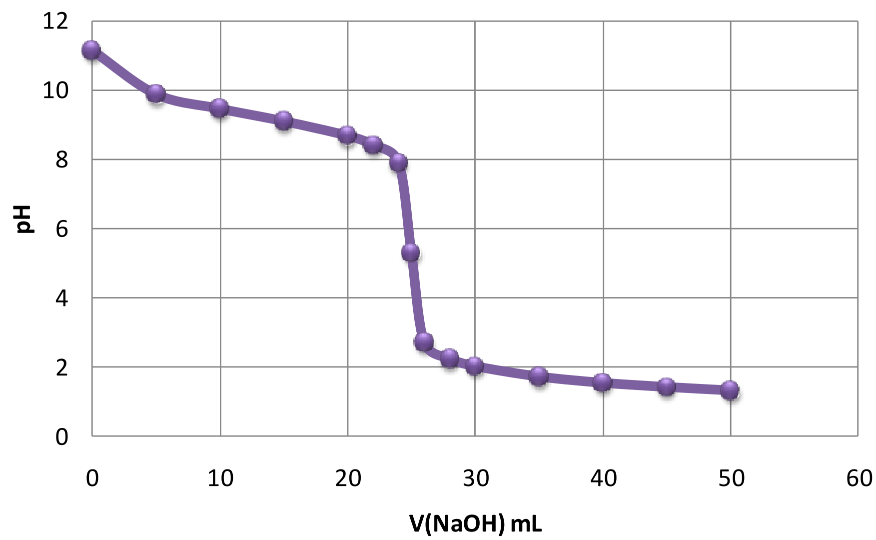
A. $CH_3COOH_{(aq)}$ with $NaOH_{(aq)}$

B. $HCl_{(aq)}$ with $NH_{3(aq)}$

C. $HCl_{(aq)}$ with $NaOH_{(aq)}$

D. $H_2S_{(aq)}$ with $NaOH_{(aq)}$

13. During a titration experiment, the following graph was recorded:



The graph plotted belongs to a titration between

A. $CH_3COOH_{(aq)}$ with $NaOH_{(aq)}$

B. $NH_{3\,(aq)}$ with $HCl_{(aq)}$

C. $HCl_{(aq)}$ with $NaOH_{(aq)}$

D. $H_2S_{(aq)}$ with $NaOH_{(aq)}$

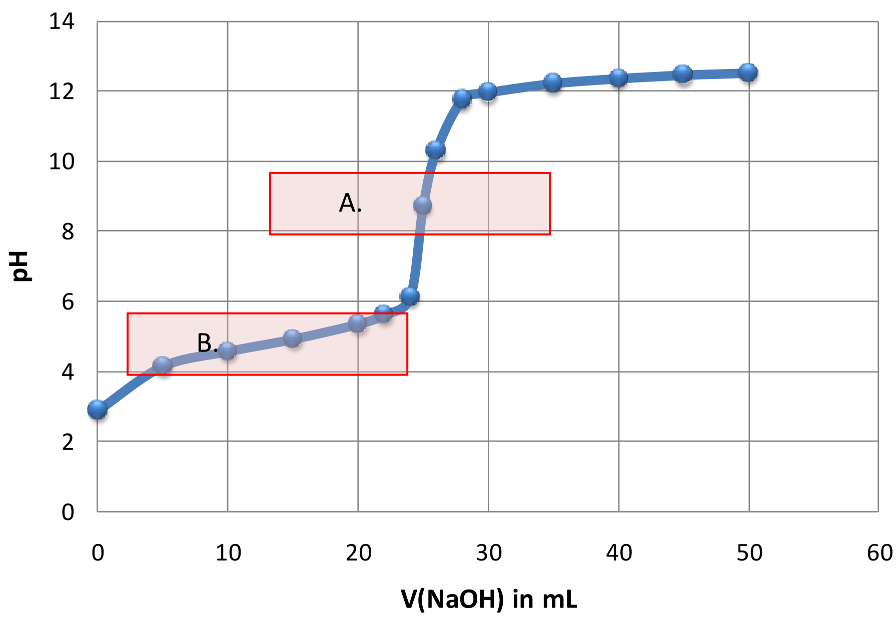
NR 4 Use the following information to answer the next question.

The following data were obtained for 0.100 mol/L acid solutions:

Acids	K_a
1. U(aq)	5.2×10^{-16}
2. X(aq)	5.3×10^{-4}
3. Y(aq)	1.8×10^{-5}
4. Z(aq)	6.9×10^{-2}

When the acids are ranked according to increasing pH, they are: _____, _____, _____, and _____.

NR 5 Weak acid-strong base titration curve



The buffer region is marked by the letter __.

14. Use the following information to answer this question.

A technician has been given two unlabelled basic solutions. One is a weak base and one is a strong base, but they have the same pH.

Which of the following statements about the two bases is true?

A. The weak base dissociates 100 % and is more concentrated than the strong base.
B. The strong base dissociates less than 100 % and is more concentrated than the weak base.
C. The weak base dissociates less than 100 % and is less concentrated than the strong base.
D. The strong base dissociates 100 % and is less concentrated than the weak base.

NR 6 Determine the equilibrium constant for the following reaction, based on the equilibrium concentrations below.

$N_2O_{(g)} + NO_{2(g)} \rightleftharpoons 3NO_{(g)}$ [NO] = 0.050 mol/L [N_2O] = 0.015 mol/L [NO_2] = 0.025 mol/L
(Record your answer to three digits.)

____

15. **The synthesis of ammonia is a very exothermic reaction. If the temperature of the system is increased, the value of the equilibrium constant will:**
    A. Decrease because more product has been formed
    B. Increase because more product are formed
    C. Decrease because more reactants are formed
    D. Increase because more reactants are formed

16. **Chloroform is a colourless, sweet-smelling, dense organic compound existing in liquid form at room temperature. In the past, it was used as a yet unknown to be toxic anaesthetic. The main use of chloroform today is in the production of the chlorodifluoromethane (R-22), a major precursor to tetrafluoroethylene:**

$CHCl_3 + 2\ HF \rightleftharpoons CHClF_2 + 2\ HCl$

Find the correct equilibrium expression for the chemical reaction below:

$2\ CHClF_{2\,(g)} \rightleftharpoons C_2F_{4\,(g)} + 2\ HCl_{(g)}$

A. $K_c = \frac{[HCl]^2}{[CHClF_2]^2[C_2F_4]}$
B. $K_c = \frac{[C_2F_4][CHClF_2]}{[HCl]}$
C. $K_c = \frac{[C_2F_4][HCl]^2}{[CHClF_2]^2}$
D. $K_c = \frac{[C_2F_4]}{[CHClF_2][HCl]^2}$

17. **At a certain temperature, the equilibrium constant is 144 for the reaction:**

$ClNO_{2(g)} + NO_{(g)} \rightleftharpoons NO_{2(g)} + ClNO_{(g)}$

If 0.250 mole $ClNO_{2(g)}$ and 0.250 mole of $NO_{(g)}$ are placed in a 1 L container, what is the concentration of $NO_{2(g)}$ at equilibrium?

A. 0.490 mol/L
B. 0.231 mol/L
C. 0.124 mol/L
D. 0.250 mol/L

18. **A reaction favouring the reactants in which $HCO_3^-{}_{(aq)}$ acts as an acid is**

    A. $HCO_3^-{}_{(aq)} + HSO_4^-{}_{(aq)} \rightleftharpoons H_2SO_{4\,(aq)} + CO_3^{2-}{}_{(aq)}$
    B. $HCO_3^-{}_{(aq)} + CN^-{}_{(aq)} \rightleftharpoons HCN + CO_3^{2-}{}_{(aq)}$
    C. $HCO_3^-{}_{(aq)} + HSO_4^-{}_{(aq)} \rightleftharpoons SO_4^{2-}{}_{(aq)} + H_2CO_{3\,(aq)}$
    D. $HCO_3^-{}_{(aq)} + PO_4^{3-}{}_{(aq)} \rightleftharpoons HPO_4^{2-}{}_{(aq)} + H_2CO_{3\,(aq)}$

19. Which of the following equimolar solutions could act as a buffer system?

A. $ClO_4^-{}_{(aq)}$ / $HClO_{4(aq)}$
B. $H_2PO_4^-{}_{(aq)}$ / $H_3PO_{4(aq)}$
C. $Cl^-{}_{(aq)}$ / $HCl_{(aq)}$
D. $NO_3^-{}_{(aq)}$ / $HNO_{3(aq)}$

Silver chromate (Ag_2CrO_4) is a brown-red monoclinic crystal. It can be formed by combining silver nitrate ($AgNO_3$) and potassium chromate (K_2CrO_4). Silver chloride is used in the Mohr titration to determine chloride ion concentration. Its formation is used to indicate the endpoint in the titration of chloride with silver nitrate. The solubility of silver chromate is slightly higher than that of silver chloride. Therefore, in a mixture of both ions, silver chloride will be formed. Only when all chloride has been consumed, will silver chromate form and precipitate out.

20. Use the following information to answer this question.

The following reaction is an example of an equilibrium system.
$Ag^+{}_{(aq)} + CrO_4^{2-}{}_{(aq)} \rightleftharpoons Ag_2CrO_{4\,(s)}$

The equilibrium constant for the above reaction is given as

A. $K_{eq} = \frac{1}{[Ag^+][CrO_4{}^{2-}]}$

B. $K_{eq} = \frac{[Ag_2CrO_4]}{[Ag^+][CrO_4{}^{2-}]}$

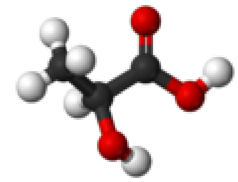
C. $K_{eq} = \frac{[Ag_2CrO_4][CrO_4{}^{2-}]}{[Ag^+]}$

D. $K_{eq} = [Ag^+][CrO_4{}^{2-}]$

21. Which of the following rows correctly identifies the correct equilibrium equation and colour of the solution if a few drops of bromothymol blue are added to a solution of nitrous acid:

A. $HNO_{2(aq)} + Bb^-{}_{(aq)} \rightleftharpoons NO_2^-{}_{(aq)} + HPB_{(aq)}$ solution is blue
B. $HNO_{2(aq)} + Bb^-{}_{(aq)} \rightleftharpoons NO_2^-{}_{(aq)} + HPB_{(aq)}$ solution is yellow
C. $HNO_{2(aq)} + Bb^-{}_{(aq)} \rightleftharpoons NO_2^-{}_{(aq)} + HPB_{(aq)}$ solution is red
D. $HNO_{2(aq)} + HPB_{(aq)\,(aq)} \rightleftharpoons NO_2^-{}_{(aq)} + Bb^-{}_{(aq)}$ solution is blue

Lactic acid is a hydroxyl carboxylic acid which plays a role in several biochemical processes. It was first isolated by the Swedish chemist Carl Wilhelm Scheele in 1780 from sour milk.



22. Use the following information to answer the next question

$$C_2H_5OCOOH_{(aq)} + H_2O_{(l)} \rightleftharpoons C_2H_5OCOO^-_{(aq)} + H_3O^+_{(aq)}$$

K_{eq}=1.4x10^{-4}

The equilibrium law expression for the equation above is (i), and at equilibrium the concentration of reactant is (ii) than the concentration of product.

A. (i) $K_{eq} = \frac{[C_2H_5OCOO^-][H_3O^+]}{[C_2H_5OCOOH][H_2O]}$ (ii) greater

B. (i) $K_{eq} = \frac{[C_2H_5OCOO^-][H_3O^+]}{[C_2H_5OCOOH]}$ (ii) greater

C. (i) $K_{eq} = \frac{[C_2H_5OCOO^-]}{[C_2H_5OCOOH][H_3O^+]}$ (ii) greater

D. (i) $K_{eq} = \frac{[C_2H_5OCOO^-][H_3O^+]}{[C_2H_5OCOOH]}$ (ii) less

23. The Brønsted-Lowry bases in the equation below are:

$$HCO_3^-{}_{(aq)} + HSO_4^-{}_{(aq)} \rightleftharpoons H_2CO_{3\,(aq)} + SO_4^{2-}{}_{(aq)}$$

A. $HCO_3^-{}_{(aq)}$ and $SO_4^{2-}{}_{(aq)}$
B. $HSO_4^-{}_{(aq)}$ and $SO_4^{2-}{}_{(aq)}$
C. $H_2CO_{3(aq)}$ and $HSO_4^-{}_{(aq)}$
D. $H_2CO_{3(aq)}$ and $SO_4^{2-}{}_{(aq)}$

24. Which of the following compounds can act as a Brønsted-Lowry acid?

A. $NH_{3(aq)}$
B. $NaOH_{(aq)}$
C. $HCOOH_{(aq)}$
D. $NO_2^-{}_{(aq)}$

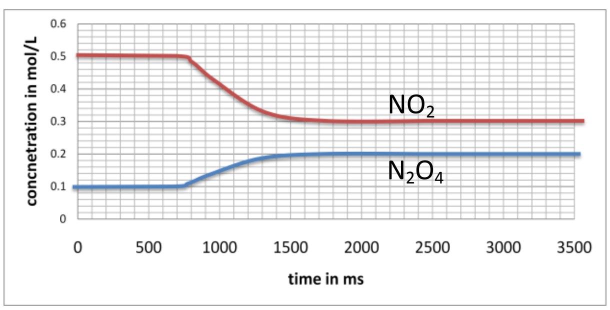
25. 50 mL of a 1 mol/L solution of acetic acid solution is mixed with 50 mL of a 1 mol/L sodium acetate solution. If a very small amount of sodium hydroxide is added to the resulting buffer solution, then what happens to the pH (i), and which way will the equilibrium shift (ii)?
$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COO^-_{(aq)} + OH^-_{(aq)}$

A. (i) the pH increases and (ii) the equilibrium shifts to the product side
B. (i) the pH does not change and (ii) the equilibrium shifts to the product side
C. (i) the pH does not change and (ii) the equilibrium shifts to the reactant side
D. (i) the pH increases and (ii) the equilibrium shifts to the reactant side

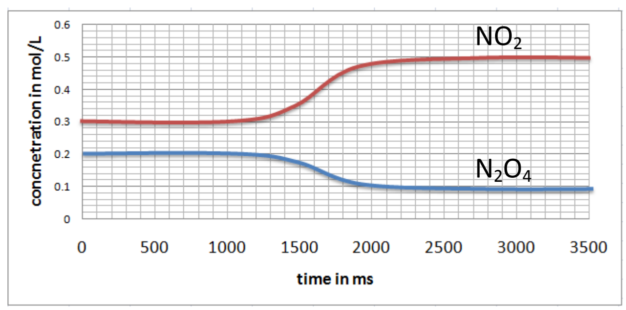
26.

The graphs below show the relative concentrations of $NO_{2\,(g)}$ and $N_2O_{4\,(g)}$ as various stresses are exerted on the equilibrium system $2NO_{2\,(g)} \rightleftharpoons N_2O_{4\,(g)} + 48.2$ kJ/mol

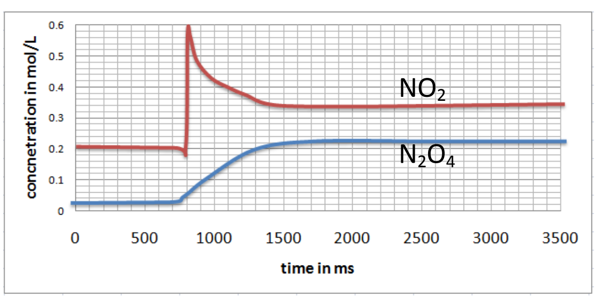
Graph A



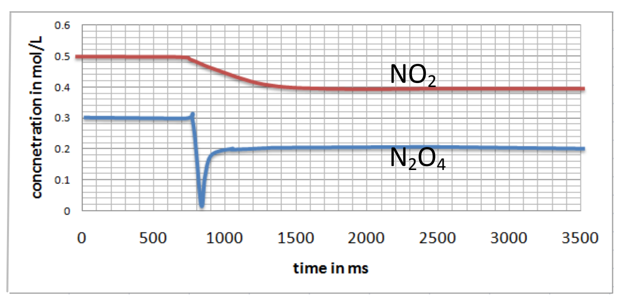
Graph B



Graph C



Graph D



Which graph represents a decrease in temperature (i) and which graph represents adding nitrogen dioxide (ii), as stresses applied to the system above?

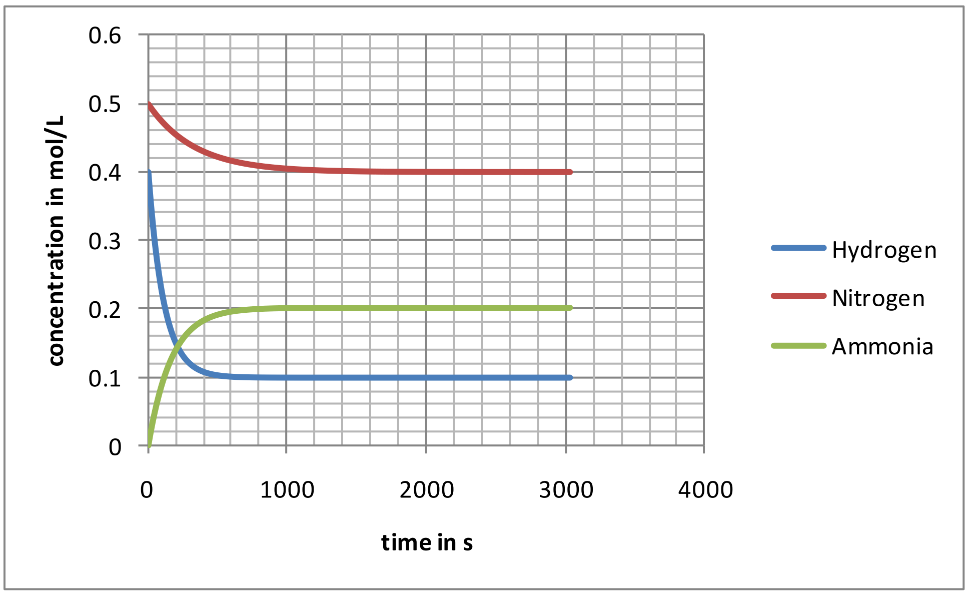
A. (i) graph A and (ii) graph C
B. (i) graph B and (ii) graph C
C. (i) graph B and (ii) graph D
D. (i) graph A and (ii) graph D

NR 8

Ammonia is produced in the Haber–Bosch process, in which nitrogen gas and hydrogen gas react, over an enriched iron or ruthenium catalyst.

$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

An experiment to investigate this reaction yielded the following data:



At what time was equilibrium first reached in this experiment?

_ _._ minutes

Solutions

1. C

$$K_a \times K_b = K_w = 1 \times 10^{-14} = 3.5 \times 10^{-8} \times K_b$$

Solve for K_b
$K_b = 2.9 \times 10^{-7}$

2. D

Mole ratio:

$$\frac{n\ OCl^-}{n\ I^-} = \frac{1\ mol}{2\ mol}$$

Solve for $n\ OCl^-$

$$n\ OCl^- = \frac{1\ mol}{2\ mol} \times n\ I^-$$

Remember: n=cV

Substitute n by cV

$$(c \times V)OCl^- = \frac{1\ mol}{2\ mol} \times (c \times V)\ I^-$$

Solve for the concentration of

$$cOCl^- = \frac{1\ mol}{2\ mol} \times \frac{(c \times V)\ I^-}{VOCl^-}$$

$$cOCl^- = \frac{1\ mol}{2\ mol} \times \frac{(10\ mL \times 0.05\ mol)\ I^-}{50\ mL\ OCl^-\ L} = 0.005\ mol/L$$

NR 1

	$OCl^-_{(aq)} + H_2O_{(l)} \rightleftharpoons$	$OH^-_{(aq)}$ +	$HClO_{(aq)}$
I	**0.015 mol/L**	**0**	**0**
C	**-x**	**+x**	**+x**
E	**0.015 mol/L-x**	**x**	**x**

$$K_b = \frac{[OH^-][HClO]}{[OCl^-]} = \frac{x^2}{0.015 - x} = 2.9 \times 10^{-7}$$

Approximation

$$\frac{x^2}{0.015} = 2.9 \times 10^{-7}$$

Solve for x

x=6.6 x 10^{-5} = hydroxide ion concentration

pOH = -log 6.6 x 10^{-5}=4.18

pOH + pH = 14

pH=14 - 4.18=9.82

3. **Chemical systems reach equilibrium when**

C. the rates of forward and reverse reactions become equal.

4. D (adding nitrogen shifts the equilibrium to the product side and increasing the temperature also shifts this endothermic reaction to the product side)
5. A (the stronger acid HSO_4^- and the stronger base F^- are on the reactant side)
6. D [$HOOCOO^-$ can act as both an acid (lose a proton) and a base (accept a proton)]

7. B

Pyridine is a weak base

$C_5H_5N_{(aq)} + H_2O_{(l)} \rightleftharpoons C_5H_5NH^+_{(aq)} + OH^-_{(aq)}$

I	**0.20 mol/L**	**0**	**0**
C	**-x**	**+x**	**+x**
E	**0.20 mol/L –x**	**x**	**x**

$$K_b = \frac{[OH^-][B^+]}{[HB]} = \frac{x^2}{0.2 - x} = 1.8 \times 10^{-9}$$

Approximation

$$K_b = \frac{[OH^-][B^+]}{[HB]} = \frac{x^2}{0.2} = 1.8 \times 10^{-9}$$

Solve for x

x= 1.9x10^{-5}= hydroxide ion concentration

-log 1.9x10^{-5}=pOH=4.72

pH=14 – 4.72 =9.28

8. D

Phosphoric acid is triprotic (H_3PO_4)

9. C

$$K_{a1} = \frac{[H_3O^+][H_2PO_4^{\ -}]}{[H_3PO_4]} \quad K_{a2} = \frac{[H_3O^+][HPO_4^{\ 2-}]}{[H_2PO_4^{\ -}]} \quad K_{a3} = \frac{[H_3O^+][PO_4^{\ 3-}]}{[HPO_4^{\ 2-}]}$$

NR 2

	$HA_{(aq)} + H_2O_{(aq)} \rightleftharpoons$	$H_3O^+_{(aq)}$ +	$A^-_{(aq)}$
I	**0.02 mol/L**	**0**	**0**
C	**-x**	**+x**	**+x**
E	**0.02 mol/L-x**	**x**	**x**

$$K_a = \frac{[H_3O^+][A^-]}{[HA]} = \frac{x^2}{0.02 - x} = 6.3 \times 10^{-5}\ (K_a\ from\ data\ booklet)$$

Approximation

$$\frac{x^2}{0.02} = 6.3 \times 10^{-5}$$

Solve for x

x=0.00112= hydronium ion concentration

pH = 2.95

10. D

The function of chemical buffers in the blood is to

D. Maintain a constant pH when a small amount of acid or base is added

11. C

Which of the following pairs are the conjugate acid base pairs of the reaction of ascorbic acid with water?

C. $H_2C_6H_6O_{6(aq)}$/ $HC_6H_6O_6^{-}{}_{(aq)}$ and $H_2O_{(l)}$ /$H_3O^+{}_{(aq)}$

NR 3

Same procedure as question NR 2

pH= 3.34

12. C

The graph plotted belongs to a titration between

C. $HCl_{(aq)}$ with $NaOH_{(aq)}$
(equivalence point = 7 -> titration between strong acid and strong base)

13.

The graph plotted belongs to a titration between

B. $NH_{3\,(aq)}$ with $HCl_{(aq)}$

Titration of a weak base with a strong acid

The pH at the equivalence point is less than 7 due to the hydrolysis of the NH_4^+ ion

$NH_4^+{}_{(aq)} \rightleftharpoons NH_{3\,(aq)} + H^+{}_{(aq)}$

NR 4

	Z	X	Y	U
pH	1.1	2.1	2.9	8.1

(the greater the K_a value the stronger a weak acid->the higher the hydronium ion concentration ->the lower the pH

NR 5

B. = buffer region (pH stays nearly constant in this region)

14. D

Which of the following statements about the two bases are true?

The strong base dissociates 100 % and is less concentrated than the weak base.

NR 6

$$K_{eq} = \frac{[NO]^3}{[NO_2][N_2O]} = \frac{0.05^3}{0.015 \times 0.025} = 0.33$$

15. C

The synthesis of ammonia is a very exothermic reaction. If the temperature of the system is increased, the value of the equilibrium constant will:

Decrease because more reactants are formed

16. C

$$K_c = \frac{[C_2F_4][HCl]^2}{[CHClF_2]^2}$$

17. B

	$ClNO_{2(g)}$ +	$NO_{(g)}$ $\rightleftharpoons$	$NO_{2(g)}$ +	$ClNO_{(g)}$
I	0.250 mol/L	0.250 mol/L	0	0
C	-x	-x	+x	+x
E	0.250 mol/L-x	0.250 mol/L-x	x	x

$$K_{eq} = \frac{[NO_2][ClNO]}{[NO][ClNO_2]} = \frac{x^2}{(0.250 - x)^2} = 144$$

Solve for x

Square root on both sides

$$K_{eq} = \frac{[NO_2][ClNO]}{[NO][ClNO_2]} = \frac{x}{(0.250 - x)} = 12$$

$$x = 12 \times (0.250 - x)$$

$$x = 3 - 12x$$

$$13x = 3$$

$$x = \frac{3}{13} = 0.231$$

18.

A reaction favouring the reactants in which $HCO_3^-{}_{(aq)}$ acts as an acid is

A. $HCO_3^-{}_{(aq)} + HSO_4^-{}_{(aq)} \rightleftharpoons H_2SO_{4(aq)} + CO_3^{2-}{}_{(aq)}$

($HCO_3^-{}_{(aq)}$ act as an acid and donates its proton to $HSO_4^-{}_{(aq)}$ and the stronger acid and base are on the product side therefore favouring the reactants)

19. B

Which of the following equimolar solutions could act as a buffer system?

$H_2PO_4^-{}_{(aq)}$ / $H_3PO_{4(aq)}$

(a buffer consists of a mixture of a weak acid/base and its conjugate weak base/acid)

20. A

$$\boldsymbol{K_{eq} = \frac{1}{[Ag^+][CrO_4{}^{2-}]}}$$

(do not include solids in equilibrium expression)

21. B

Which of the following rows correctly identifies the correct equilibrium equation and colour of the solution if a few drops of bromothymol blue are added to a solution of nitrous acid:

$HNO_{2(aq)} + Bb^{-}_{(aq)} \rightleftharpoons NO_2^{-}{}_{(aq)} + HPB_{(aq)}$ solution is yellow

(see data booklet bromothymol blue $HPB_{(aq)}$/ $Bb^{-}{}_{(aq)}$ pH 6.0-7.6 yellow/blue)

22. B

(i) $K_{eq} = \frac{[C_2H_5OCOO^-][H_3O^+]}{[C_2H_5OCOOH]}$ (ii) greater

(weak acid (small Ka value) only ionizes to a very small percentage)

23. A

The Brønsted-Lowry bases in the equation below are:

$HCO_3^{-}{}_{(aq)}$ and $SO_4^{2-}{}_{(aq)}$

(both act as a base by accepting a proton)

24. C

$HCOOH_{(aq)}$

(can react with water to produce hydronium ions)

25. C

(i) the pH does not change and (ii) the equilibrium shifts to the reactant side

(adding a small amount of acid or base will not change the pH of a buffer solution)

26. A

(i) graph A and (ii) graph C

[decreasing the temperature will favour the product side (the reaction is exothermic) and adding nitrogen dioxide will also shift the equilibrium to the product side)]

NR 8

Equilibrium is reached after 16.6 minutes