18.1 Further Aspects of Acids & Bases

Question Paper

Course	DP IB Chemistry
Section	18. Acids & Bases (HL only)
Topic	18.1 Further Aspects of Acids & Bases
Difficulty	Medium

Time allowed: 80

Score: /63

Percentage: /100

Question 1a

a)
Iron(III) ions can react with cyanide ions to form ferricyanide ion via the following equation

$$Fe^{3+} + 6CN^- \rightarrow [Fe(CN)_6]^{3-}$$

State which of the reactants is behaving as a Lewis base and justify your answer.

[2 marks]

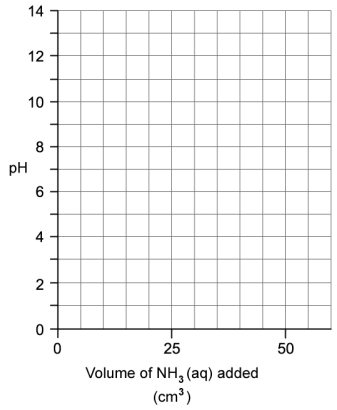
Question 1b

b)
State the definition of a Brønsted-Lowry acid and the equation which demonstrates how ethanoic acid, $CH_3COOH\,(aq)$, behaves as a Brønsted-Lowry acid when reacting with ammonia, $NH_3\,(aq)$.

[2 marks]

Question 1c

c)
Sketch a graph to indicate the change in pH during a titration of 25.0 cm^3 of 0.100 mol dm^{-3} hydrochloric acid, $HCl\,(aq)$, with 0.100 mol of ammonia, $NH_3\,(aq)$.



[2 marks]

Question 1d

d)
The end point in a titration can be identified using a suitable indicator.

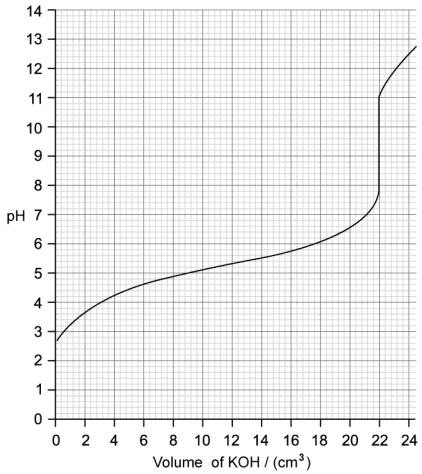
i)
Using Section 22 of the Data Booklet, select a suitable indicator that could be used for this titration and justify your choice.
ii)
Describe how an acidic indicator works.

[5 marks]

Question 2a

a)

Ethanoic acid, $CH_3COOH\,(aq)$, is titrated with 0.16 mol dm^{-3} potassium hydroxide and the following graph is obtained.



Explain why the equivalence point is greater than pH 7 for this titration.

[3 marks]

Question 2b

b)

Explain what is meant by a buffer solution and describe where the 'buffer region' on the graph would occur.

[2 marks]

Question 2c

c)

Explain the shape of the pH curve up to the equivalence point.

[4 marks]

Question 2d

d)
Explain why potassium hydroxide can act as a Brønsted-Lowry base and Lewis base.

[3 marks]

Question 3a

a)
This question is about Brønsted-Lowry acids and bases.

i)
Give the meaning of the term Brønsted-Lowry acid.

ii)
Explain the term weak acid.

[3 marks]

Question 3b

b)
When an acid and a base react they produce a conjugate base and a conjugate acid.

$$\text{acid} + \text{base} \rightleftharpoons \text{conjugate base} + \text{conjugate acid}$$

Write an equation to show how hydrochloric acid behaves as a strong acid when it reacts with water, and state the role of water in this reaction.

[2 marks]

Question 3c

c)
Ethanoic acid is a weak acid. Hydrogen carbonate ions can also act as a weak acid if in an aqueous solution.

i)
Write equations for each of these weak acids at equilibrium.

ii)
A solution was made up containing sodium hydrogen carbonate and sodium carbonate. Explain how this solution would act as a buffer if a small amount of acid was added to it.

[4 marks]

Question 3d

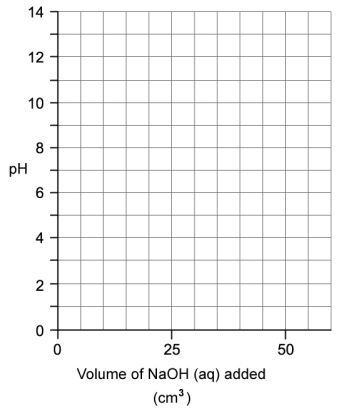
d)
Explain how a solution containing ethanoic acid and ethanoate ions can act as a buffer.

[4 marks]

Question 4a

a)
A student performed a titration of 25.0 cm^3 of 0.100 mol dm^{-3} hydrochloric acid, HCl (aq) , with 0.100 mol of sodium hydroxide, NaOH (aq).

i)
Draw the expected pH curve on the graph and indicate the equivalence point for this.



ii)
Explain why the salt produced in this reaction is neutral.

[5 marks]

Question 4b

b)
The student repeated the titration using two different chemicals, 25.0 cm^3 of 0.100 mol dm^{-3} nitric acid, HNO_3 (aq) , and 0.100 mol dm^{-3} ammonia, NH_3 (aq).

i)
State the equation for this reaction.

ii)
Explain why the salt produced in this reaction is acidic.

[5 marks]

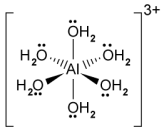
Question 4c

c)
State the equation for reaction between nitric acid and water, this reaction and identify the conjugate acid formed in the reaction.

[2 marks]

Question 4d

d)
The image below shows the hexaaquaaluminium ion, $[Al(H_2O)_6]^{3+}$. Explain why this can behave as an acid.

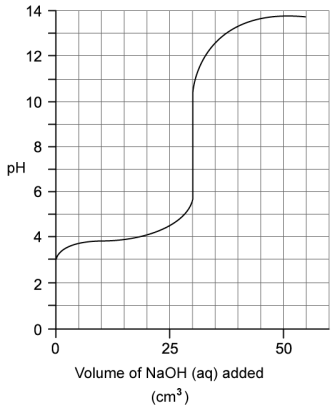


[3 marks]

Question 5a

a)

25.0 cm^3 of 0.100 mol dm^{-3} propanoic acid, CH_3CH_2COOH (aq) , is titrated with of 0.100 mol dm^{-3} sodium hydroxide. The pH curve for this titration is shown below.



i)

Label the equivalence point and half equivalence point on the curve

ii)

Explain what is meant by the half equivalence point.

[3 marks]

Question 5b

b)

The student used the pH range of the indicators to determine which was the best one to use for this titration.

i)

Using Section 22 of the Data Booklet highlight on the graph the pH range of bromocresol green for this titration.

ii)

Using Section 22 of the Data Booklet suggest a suitable choice of indicator for this titration and state the colour change you would expect to see.

[3 marks]

Question 5c

c)
The end point of an indicator depends on its pK_a

i)
Explain the connection between the pH range of an indicator that is a weak acid and the value of pK_a for the indicator.

ii)
Explain how the student can calculate the K_a of propanoic acid by using the pH curve.

[5 marks]

Question 5d

d)
A buffer solution contains a mixture of propanoic acid and its salt. A small amount of nitric acid is added to the buffer.

Write an equation, including state symbols, showing how this buffer can resist the change in pH.

[1 mark]