Chemistry

2015 Term 1
Theory Examination

General Instructions

- Reading time – 3 minutes
- Working time – 45 minutes
- Write using black or blue pen
- Write your Student Number at the top of the response sheet on page 7 and on the response sheet.
  A data sheet and a periodic table are provided at the back of the paper and may be removed for student convenience.

Theory

Total Marks – 43

Part A – 12 marks
Attempt Questions 1 – 12

Part B – 31 marks
Attempt Questions 13-19

Part A- Multiple Choice 12 marks
Attempt Questions 1-12
Allow about 15 minutes for this part

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

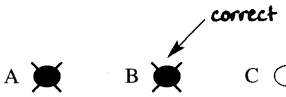
Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ⊗ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.



▸ **Mark your answers for Questions 1- 12 in the Answer Box on page 7**

1. What is the Bronsted-Lowry definition of an acid?

(A) A proton acceptor

(B) A proton generator

(C) A proton producer

(D) A proton donor

2. 1.0 mL of 10 mol L^{-1} hydrochloric acid is diluted to 1.0 L with distilled water. 100.0 mL of this solution is then further diluted to 1.0 L using distilled water.

What is the final pH of the solution?

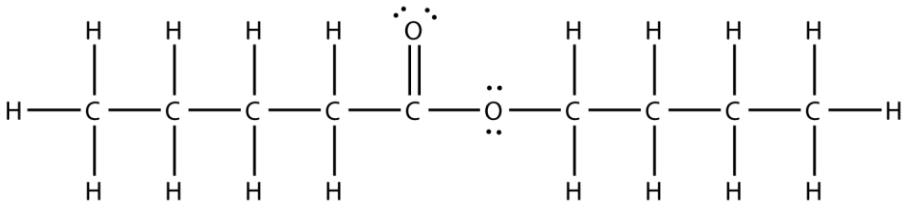
(A) 0

(B) 2

(C) 3

(D) 7

3. What is the correct name for the following compound?



(A) Pentylbutanoate

(B) Pentylbutanoic acid

(C) Butylpentanoate

(D) Butylpentanoic acid

4. Which statement best describes the need for refluxing in esterification?

(A) To provide high enough temperature and pressure for the formation of product.

(B) To catalyse the reaction.

(C) To allow the equilibrium to shift to the right to favour formation of product.

(D) To prevent volatile gases from escaping while providing high temperature.

5. Which of the following shows the reactants in the formation of an ester?

(A) Ethanoic acid + sodium hydrogen carbonate

(B) Ethanoic acid + ethanol

(C) Ethanoic acid + sodium hydroxide

(D) Ethanoic acid + ethylbenzoate

6. The following equation represents a chemical system in equilibrium:

$CH_3COO^-(aq) + H_2O(l) \rightleftharpoons CH_3COOH(l) + OH^-(aq)$

Which of the following is a conjugate acid/base pair?

(A) CH_3COO^- / CH_3COOH

(B) CH_3COO^- / H_2O

(C) CH_3COOH / OH^-

(D) H_2O / CH_3COOH

7. Which indicator could be used to identify the end point of a titration between solutions of NH_3 and HCl?

	Acid Range Colour	*Colour-Change pH*	*Basic Range Color*
(A)	Pink	1.2 - 2.8	Yellow
(B)	Blue	3.4 - 4.6	Yellow
(C)	Yellow	6.5 - 7.8	Purple
(D)	Colourless	8.3 - 9.9	Red

8. Which of the following quantities of matter, when reacted at 25°C with excess hydrochloric acid, would give the largest volume of a gaseous product?

(A) 50 g of calcium carbonate

(B) 50 g of zinc metal

(C) 50 g sodium carbonate

(D) 50 g of sodium metal

9. Given the equilibrium system at 25°C:

$$NH_4Cl(s) \rightleftharpoons NH_4^+(aq) + Cl^-(aq) \qquad \Delta H = +3.5 \text{ kJ mol}^{-1}$$

Which change will shift the equilibrium to the right?

(A) decreasing the temperature to 15°C

(B) increasing the temperature to 35°C

(C) dissolving NaCl crystals in the equilibrium mixture

(D) dissolving NH_4NO_3 crystals in the equilibrium mixture

10. Consider a reaction mixture which is at equilibrium and is represented by the following equation:

$$NH_3\,(g) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

What effect will the addition of a few drops of hydrochloric acid have on the position of the equilibrium?

(A) Shift to the right.

(B) Shift to the left.

(C) Move to completion.

(D) No change.

11. Which of the following is the most basic oxide?

(A) N_2O_3

(B) N_2O_5

(C) CaO

(D) Bi_2O_5

12. Which species is amphiprotic?

(A) SO_4^{2-}

(B) OH^-

(C) HCO_3^-

(D) HF

Student Number	
Theory Mark / 43	

Part A: Answer grid for multiple choice questions.

1.	A O	B O	C O	D O
2.	A O	B O	C O	D O
3.	A O	B O	C O	D O
4.	A O	B O	C O	D O
5.	A O	B O	C O	D O
6.	A O	B O	C O	D O
7.	A O	B O	C O	D O
8.	A O	B O	C O	D O
9.	A O	B O	C O	D O
10.	A O	B O	C O	D O
11.	A O	B O	C O	D O
12.	A O	B O	C O	D O

Part B 31 marks

Attempt Questions 13 – 19

Allow about 30 minutes for this part

- ***Show all relevant working in questions involving calculations.***

Question 13 (4 marks) **Marks**

Describe the difference between a strong and a weak acid in terms of an equilibrium between the molecules and its ions using one example of each. Use relevant chemical equations in your answer. **4**

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Question 14 (2 marks)

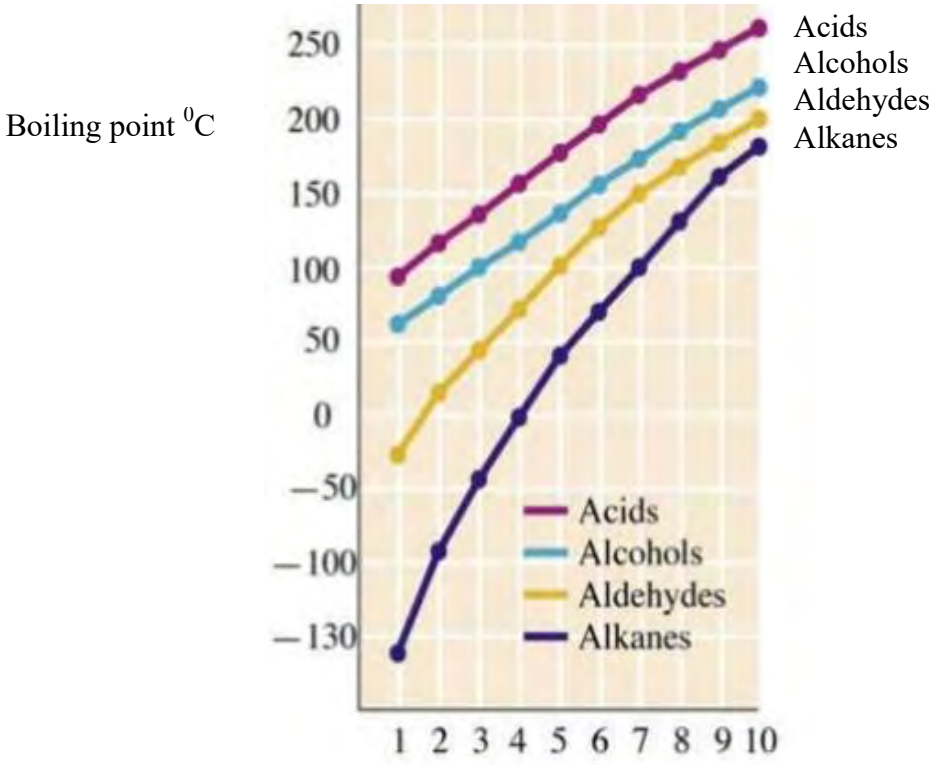
Give the systematic name and draw the structural formula for citric acid. **2**

Name :……

Question 15 (4 marks)

The graph shows the boiling points of straight-chain alkanols and straight-chain alkanoic acids. **4**

Explain the difference in the boiling points of these two homologous series using data from the graph.



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Question 16 (2 marks)

Explain the use of acids as food additives including two examples of acids which are used as additives. **2**

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Question 17 (4 marks)

Discuss why the oxides of sulfur are causing concern when released into the atmosphere. **4**

Use equations to support your answer.

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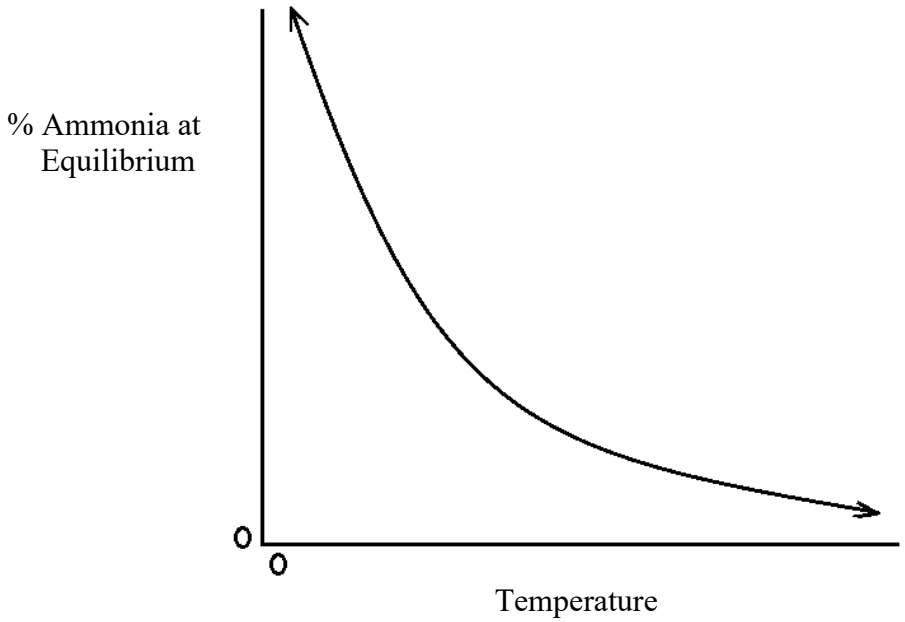
Question 18 (9 marks)

Chemical systems in industry need to be monitored continuously so that yields are maximised. The Haber Process is an example of such a process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The following graph shows how the percentage of ammonia in the equilibrium mixture changes with temperature.



(a) Explain what this graph indicates about the exothermic/endothermic nature of the process. **2**

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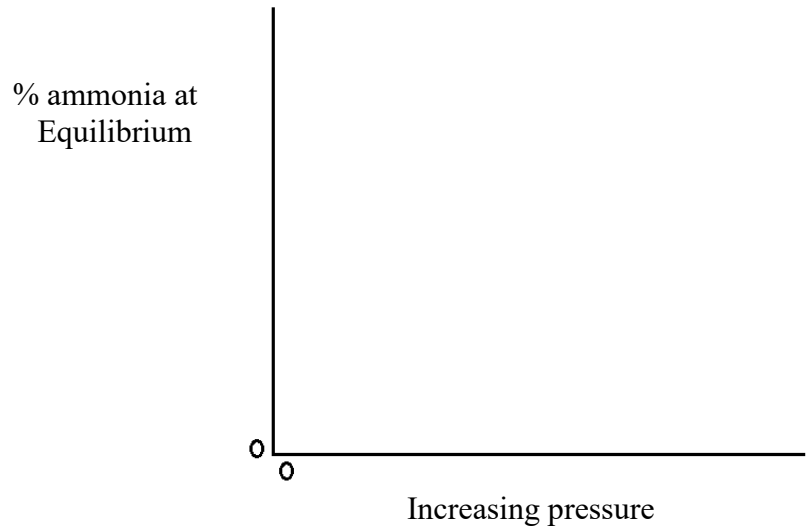
(b) Sketch a graph which shows how the percentage of ammonia in the equilibrium mixture varies with pressure. **1**



(c) Explain why the graph has the shape you have drawn. **2**

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(d) Use both graphs to justify the conditions of temperature and pressure that are used in the industrial production of ammonia. **4**

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Question 19 (6 marks)

Oxalic acid dehydrate $H_2C_2O_4.2H_2O$ can be obtained in very pure form and is very stable. It can therefore be used as a primary standard in volumetric analysis. It's a weak diprotic acid.

A 3.276 g sample of this substance was dissolved in water and the volume made up to 250 mL in a volumetric flask. This solution was then used to standardise a sodium hydroxide solution.

(a) Calculate the concentration of the oxalic acid solution. **2**

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(b) Select a suitable indicator for the titration, giving a reason for your selection. **2**

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(c) Outline *two* reasons why sodium hydroxide is not suitable as a primary standard. **2**

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End of Theory Test

Year 12 Chemistry Theory Answers Term 1 2015

Part A: Answer grid for multiple choice questions.

1.	A O	B O	C O	D √
2.	A O	B O	C √	D O
3.	A O	B O	C √	D O
4.	A O	B O	C O	D √
5.	A O	B √	C O	D O
6.	A √	B O	C O	D O
7.	A O	B √	C O	D O
8.	A O	B O	C O	D √
9.	A O	B √	C O	D O
10.	A √	B O	C O	D O
11.	A O	B O	C√	D O
12.	A O	B O	C√	D O

1. What is the Bronsted-Lowry definition of an acid?

   (A) A proton acceptor

   (B) A proton generator

   (C) A proton producer

   (D) A proton donor

Outcomes : H6

2. 1.0 mL of 10 mol L-1 hydrochloric acid is diluted to 1.0 L with distilled water.

100.0 mL of this solution is then further diluted to 1.0 L using distilled water.

What is the final pH of the solution?

(A) 0

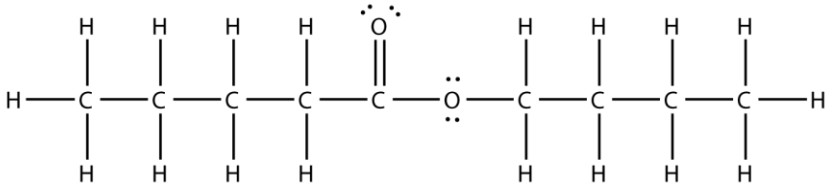
(B) 2

(C) 3

(D) 7

Outcomes : H10

3. What is the correct name for the following compound?



(A) Pentylbutanoate

(B) Pentylbutanoic acid

(C) Butylpentanoate

(D) Butylpentanoic acid

Outcomes : H9

4. Which statement best describes the need for refluxing in esterification?

(A) To provide high enough temperature and pressure for the formation of product.

(B) To catalyse the reaction.

(C) To allow the equilibrium to shift to the RHS to favour formation of product.

(D) To prevent volatile gases from escaping while providing high temperature.

Outcomes : H8

5. Which of the following is an esterification reaction?

(A) Ethanoic acid + sodium hydrogen carbonate

(B) Ethanoic acid + ethanol

(C) Ethanoic acid + sodium hydroxide

(D) Ethanoic acid + ethylbenzoate

Outcomes : H9

6. The following equation represents a chemical system in equilibrium:

CH_3COO^- (*aq*) + H_2O (*l*) $\rightleftharpoons$ CH_3COOH (*l*) + OH^- (*aq*)

Which of the following is a conjugate acid/base pair?

(A) CH_3COO^- / CH_3COOH

(B) CH_3COO^- / H_2O

(C) CH_3COOH / OH^-

(D) H_2O / CH_3COOH

Outcomes : H

7. Which indicator could be used to titrate aqueous NH_3 with HCl solution?

	Acid Range Colour	*Colour-Change pH*	*Basic Range Color*
(A)	Pink	1.2 - 2.8	Yellow
(B)	**Blue**	**3.4 - 4.6**	**Yellow**
(C)	Yellow	6.5 - 7.8	Purple
(D)	Colourless	8.3 - 9.9	Red

Outcomes : H

8. Which of the following quantities of matter, when reacted at 25°C with excess hydrochloric acid, would give the largest volume of a gaseous product?

(A) 50g of calcium carbonate

(B) 50g of zinc metal

(C) 50g sodium carbonate

(D) **50g of sodium metal**

Outcomes : H

9. Given the equilibrium system at 25°C:

$$NH_4Cl(s) \rightleftharpoons NH_4^+(aq) + Cl^-(aq) \qquad \Delta H = +3.5\ kJmol^{-1}$$

Which change will shift the equilibrium to the right?

(A) decreasing the temperature to 15°C

(B) increasing the temperature to 35°C

(C) dissolving NaCl crystals in the equilibrium mixture

(D) dissolving NH_4NO_3 crystals in the equilibrium mixture

Outcomes : H

10. Consider a reaction mixture which is at equilibrium and is represented by the following equation:

$$NH_3(g) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

What effect will the addition of a few drops of hydrochloric acid have on the position of the equilibrium?

(A) Shift to the right.

(B) Shift to the left.

(C) Move to completion.

(D) No change.

Outcomes : H

11. Which of the following is the most basic oxide?

(A) N_2O_3

(B) N_2O_5

(C) CaO

(D) Bi_2O_5

Outcomes : H

12. Which species is amphiprotic?

(A) SO_4^{2-}

(B) OH^-

(C) HCO_3^-

(D) HF

Outcomes : H

Question 13 (4 marks) **Marks**

Describe the difference between a strong and a weak acid in terms of an equilibrium **4**

between the molecules and its ions using one example of each. Use relevant chemical equations in your answer.

Sample Answer ;

Hydrochloric acid is a strong acid and will ionise completely in solution thus the ionisation will go to completion and no molecules will remain when dissolved in water. This is shown with a one way arrow in the equation of ionisation

$HCl + H_2O \rightarrow H_3O^+ + Cl^-$

Ethanoic acid is a weak acid thus will ionise partially in solution (only 1% ionisation)

So an equilibrium will be established when dissolved with water where the equilibrium lies to the LHS as shown below

$CH_3COOH + H_2O \leftrightarrow H_3O^+ + CH_3COO^-$

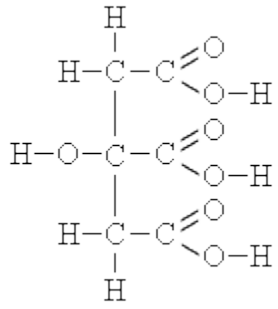
Marking Criteria

Criteria	Marks
Complete description including 2 equations	4
Complete descriptions with no equations or outline of with 2 correct equations or Description of both with one equation	3
Two correct outlines or two correct equations	2
Identifies one correct acid streght or one correct equation	1

Outcomes : H9

Question 14 (2 marks)

Give the systematic name and draw the structural formula for citric acid. **2**

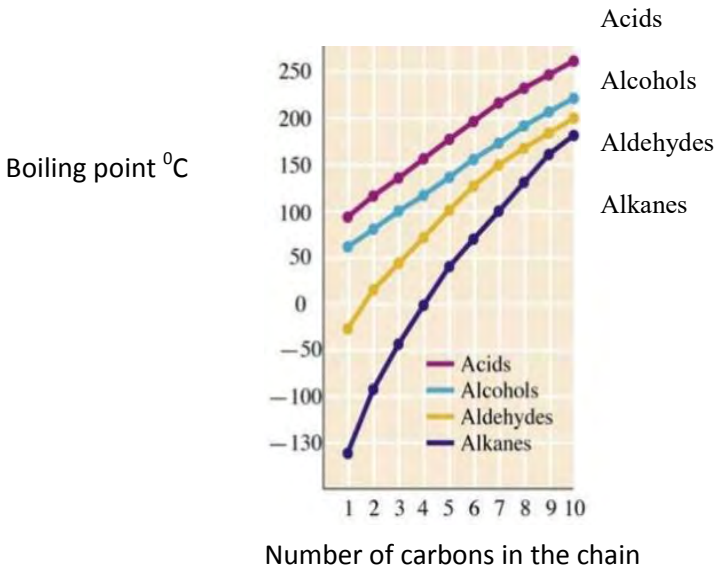


Name : 2-hydroxypropane-1,2,3-tricarboxylic acid

Criteria	Marks
Correct structural formula and name	2
Correct structural formula or name	1

Question 15 (4 marks)

The graph below includes the boiling points of straight-chain alkanols and straight-chain alkanoic acids. Explain the difference in the boiling points of these two homologous series using data from the graph. **4**



Sample answer ;

Alkanols contain –OH groups thus H-bonding occurs between molecules thus these compounds have higher boiling point compared with other hydrocarbons of similar mass

Alkanoic acids contain –C=0 and –OH groups thus the number of H-bonds formed is greater than for alkanols thus alkanoic acids have higher boiling points than other carbon compounds of similar size and mass.

Eg ethanol(2C) has a boiling point of about 80^0C while ethanoic acid has a boiling point of 110^0C.

Marking Criteria :

Criteria	Marks
Thorough explanation of the difference in b.p. of alkanols vs alkanoic acid with eg from the graph	4
Thorough explanation without example from graph	3
Description of differences in the graph of alkanols vs alkanoic acids	2
Identification of differences between alkanols vs alkanoic acids	1

Outcomes : H8, H9

Question 16 (2 marks)

Explain the use of acids as food additives including two examples of acids which **2**

are used as additives.

Acids are used to increase nutritional value, enhance the flavour of food and prevent food spoilage. Acids reduce the pH to a level where microorganisms that decompose food cannot reproduce thus food retains its use for longer without decomposing.eg. ethanoic acid, carbonic acid.

Outcomes : H9

Criteria	Marks
Correct use of organic acid with two examples	2
Correct use of organic acid with one example	1

Question 17 (4 marks)

Discuss why the oxides of sulfur are causing concern when released into the atmosphere. **4**

Use equations to support your answer.

***Sample answer**:*

Both $SO_{2(g)}$ and $SO_{3(g)}$ involved

- *Irritate respiratory system in humans. May be life threatening under some circumstances. Cause breathing difficulties. Dissolve in the $H_2O_{(l)}$ of mucous membranes to form $H_2SO_{3(aq)}$ Irritate any moist surfaces in the human body eg eyes, nose, mouth etc*
- *Form acid rain – this has the potential to destroy natural environments, destroys susceptible human constructions*

Formation of acid rain:

$SO_{3(g)} + H_2O_{(l)} \rightarrow H_2SO_{3(aq)}$

$H_2SO_{3(aq)} + \frac{1}{2}O_{2(g)} \rightarrow H_2SO_{4(aq)}$

Marking Criteria	**Marks**
Identifies the significant oxides as $SO_{2(g)}$ and $SO_{3(g)}$ Identifies one effect that is of concern Includes two correct equations showing that $SO_{3(g)}$ has the potential to form $H_2SO_{3(aq)}$ and $H_2SO_{4(aq)}$ when dissolved in $H_2O_{(l)}$	3 marks
Identifies the significant oxides as $SO_{2(g)}$ and $SO_{3(g)}$ Identifies one effect that is of concern Includes one correct equation showing that $SO_{3(g)}$ has the potential to form acid when dissolved in $H_2O_{(l)}$	2 marks
oxides $SO_{2(g)}$ and $SO_{3(g)}$ Identifies one effect that is of concern	1 mark
Equations showing formation of $SO_{2(g)}$ and $SO_{3(g)}$	No marks

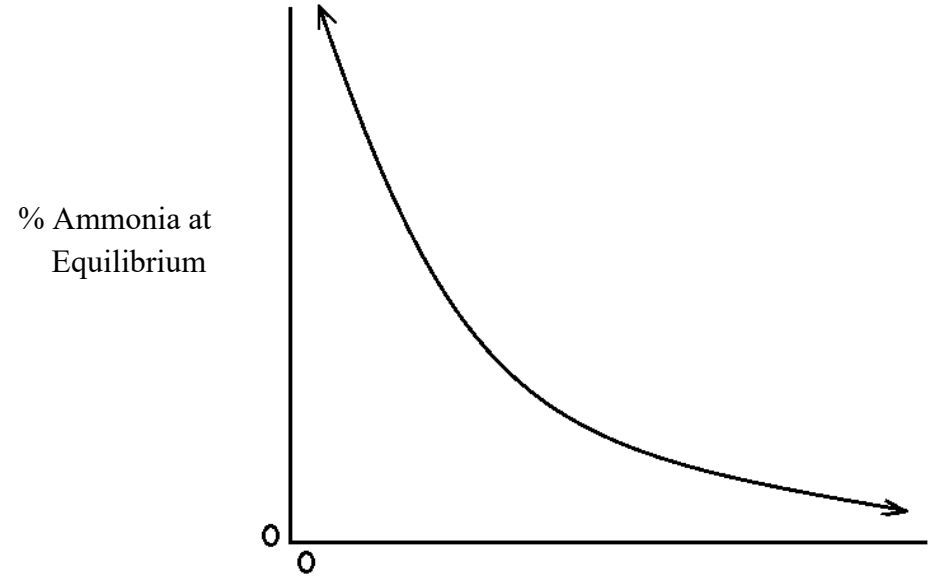
Outcomes : H

Question 18 (9 marks)

Chemical systems in industry need to be monitored continuously so that yields are maximised. The Haber Process is an example of such a process.

$$N_{2(g)} + 3H_{2(g)} \quad \leftrightarrow \quad 2NH3_{(g)}$$

The following graph shows how the percentage of ammonia in the equilibrium mixture changes with temperature.



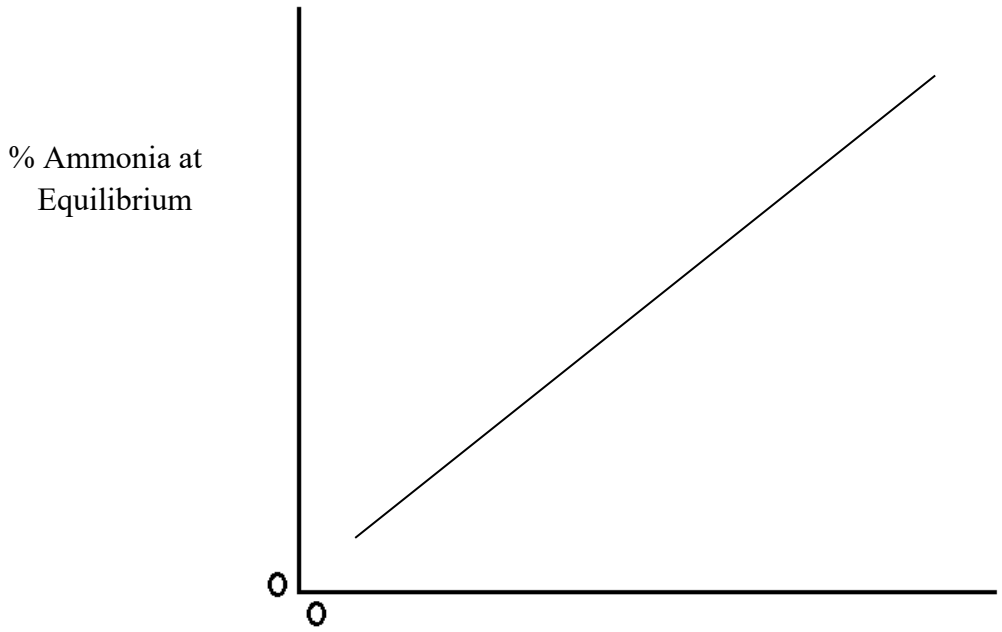
(a) Explain what this indicates about the exothermic/endothermic nature of the process. **2**

Sample answer:

As the temperature of the system increases the % ammonia decreases indicating that the reaction is exothermic in forward direction and endothermic in the reverse reaction.
Explanation: Equilibrium at each temp increase is disturbed, system shifts to minimise disturbance. Increase in temp equilibrium shifts to left to reduce temp so must be exothermic in forward direction

Answer	Marks Awarded
Correct observations made by reading graph. And Explanation of these observations.	2 marks
Correct observations made by reading graph.	1 mark

(b) Sketch a graph which shows how the percentage of ammonia in the equilibrium mixture varies with pressure. **1**



Correct shape: 1mark

(c) Explain why the graph has the shape you have drawn. **2**

Sample Answer:

System shifts to the right to minimise the effects of increase in pressure. From equation- 4 moles gas on LHS, 2 moles on RHS. Shift to the right will minimise effects of the increase in pressure.

Answer	Marks Awarded
System shifts to the right to minimise the effects of increase in pressure AND From equation- 4 moles gas on LHS, 2 moles on RHS reaction. Shift to the right will minimise effects of the increase in pressure..	2 marks
System shifts to the right to minimise the effects of increase in pressure	1 mark

(d) Use both graphs to justify the conditions of temperature and pressure that are used in the industrial production of ammonia. **4**

Outcomes : H

Sample Answer

High temperature (needed for optimum reaction rate) will push equilibrium to left so moderate temperature combined with high pressure will maximise yield of ammonia. Combination of these conditions will maximise yield of ammonia.

Answer	Marks Awarded
1. High temperature (needed for optimum reaction rate) will push equilibrium to left. AND 2. Therefore reduced temp needed. AND 3. High pressure is needed to push equilibrium to right. AND Justification: Combination of these conditions will maximise yield of ammonia.	4 marks
1. High temperature (needed for optimum reaction rate) will push equilibrium to left. OR 2. Therefore reduced temp needed. OR 3. High pressure is needed to push equilibrium to right. AND <u>Justification</u>: Combination of these conditions will maximise yield of ammonia.	3 marks Any 2 of 1,2 or 3 MUST include justification
Justification must be present and refer to temperature and pressure – no details required.	2 marks
1. High temperature (needed for optimum reaction rate) will push equilibrium to left. OR 2. Reduced temp needed. OR 3. High pressure is needed to push equilibrium to right. AND No Justification	1 mark

Question 19 (6 marks)

Oxalic acid dehydrate $H_2C_2O_4.2H_2O$ can be obtained in very pure form and is very stable.

It can therefore be used as a primary standard in volumetric analysis. It's a weak diprotic acid.

A 3.276 g sample of this substance was dissolved in water and the volume made up to

250 mL in a volumetric flask. This solution was then used to standardise a sodium hydroxide solution.

(a) Calculate the concentration of the oxalic acid solution. **2**

(b) Select a suitable indicator for the titration, giving a reason for your selection. **2**

(c) Outline two reasons why sodium hydroxide is not suitable as a primary standard **2**

1 (a) (2 marks)
Outcomes Assessed: H10
Targeted Performance Bands: 2-4

Marking Criteria	Marks
• Calculates the number of moles and molarity of oxalic acid and moles AND • Appropriate significant figures and units	2
• Calculates the molarity of oxalic acid with units correctly OR • Calculates the number of moles with units correctly	1

(a) Provide full working clearly structured for markers to assess.
M (Oxalic) = 0.1039 mol/L (4 sig figs) However, 3 sig figs is the least accurate number in the information provided therefore, M (Oxalic) = 0.104 mol/L (1)

n = m / m.m
= 3.276 / [(1.008*6) + (12.01*2) + (16*6)]
= 3.276 / 126.068
= 0.02598598 moles

M(oxalic) = n / V
= 0.02598598 / 0.25
= 0.1039439 mol/L
= 0.104 mol/L (3 sig figs)

(b) (2 marks)
Outcomes Assessed: H8 and H13
Targeted Performance Bands: 2-5

Marking Criteria	Marks
• States a correct indicator for use AND • Provides an appropriate explanation with reasons why the indicator is the best chosen	2
• States a correct indicator for use OR • Provides an appropriate explanation with reasons why the indicator is the best chosen	1

(b) Phenolphthalein, (1) as it changes colour from clear to hot pink in the basic range. The equivalence point will be within the basic range as the titration is from a strong acid & a weak base leaving the resulting salt in the basic range.(1)

(c) (2 marks)
Outcomes Assessed: H11, H12 and H13
Targeted Performance Bands: 3-5

Marking Criteria	Marks
• Outlines TWO reasons why sodium hydroxide is NOT an appropriate primary standard AND provides a related reason for each unacceptable property	2
• Outlines ONE reason why sodium hydroxide is NOT an appropriate primary standard AND provide a related reason for the unacceptable property	1

(c) NaOH absorbs water/deliquescent from the air and this will cause the mass being weighed to change regularly and(1) and
Once the solution has been created it will react with carbon dioxide in the air. (1)