Chemistry

2016 Term 1
Theory Examination

General Instructions

- Reading time – 5 minutes
- Working time – 50 minutes
- Write using black or blue pen
- Write your Student Number at the top of the response sheet on page 9.

A data sheet and a periodic table are provided.

Theory

Total Marks – 43

Part A – 12 marks
Attempt Questions 1 – 12

Part B – 30 marks
Attempt Questions 13-19

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

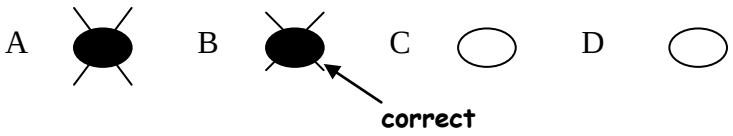
Use the multiple-choice answer sheet.

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

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

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 9**

1. An upset stomach may be caused by the presence of too much hydrochloric acid. This is often remedied by swallowing an antacid tablet which neutralizes this excess acid.

   Which of the following would be an effective ingredient in an antacid tablet?

   (A) sodium chloride

   (B) sodium hydroxide

   (C) citric acid

   (D) sodium bicarbonate

2. For the Haber process, the nitrogen required is obtained from

   (A) air

   (B) natural gas

   (C) natural nitrates

   (D) ammonia

3. Which catalyst is used in the Haber process?

   (A) iron oxide

   (B) zeolites

   (C) concentrated sulfuric acid

   (D) platinum

4. Swimming pool owners sometimes add sodium hydrogen sulfate ($NaHSO_4$) to reduce the pH of the water.

Which chemical reaction below occurs to reduce the pH of pool water?

(A) $HSO_4^-(aq) + H_2O(l) \rightarrow H_2SO_4(aq) + OH^-(aq)$

(B) $HSO_4^-(aq) + H_2O(l) \rightarrow H_3O^+(aq) + SO_4^{2-}(aq)$

(C) $2HSO_4^-(aq) \rightarrow H_2SO_4(aq) + SO_4^{2-}(aq)$

(D) $Na^+(aq) + H_2O(l) \rightarrow NaOH(aq) + H^+(aq)$

5. Ethanoic acid is a weak acid and nitric acid is a strong acid.

Which of the following tests would NOT be useful in distinguishing between them, when given a 1.0 $molL^{-1}$ solution of each acid?

(A) Measuring the pH of each solution.

(B) Measuring the conductivity of each solution.

(C) Measuring how much sodium hydroxide is needed to neutralize each acid.

(D) Observing the rate at which hydrogen is evolved from a piece of Mg placed in 5.0 mL of each acid in separate test-tubes.

6. Which of the following is an acidic oxide?

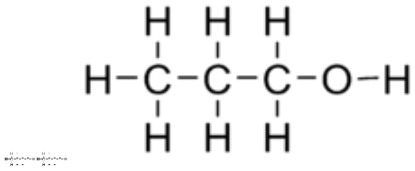
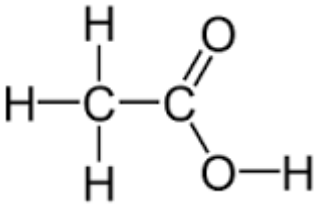
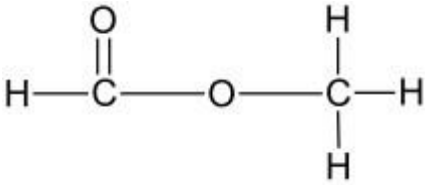
(A) NO_2

(B) N_2O

(C) Na_2O

(D) SiO_2

7. The table shows information about three carbon compounds.

Compound	Structural formula	Molecular Weight (g)	Boiling Point (^{o}C)
X		60	?
Y		60	117
Z		60	32

Which is the closest estimate for the boiling point of X?

(A) 30^{o}C

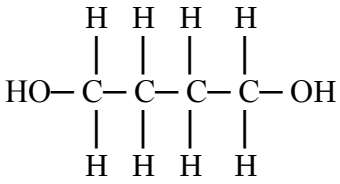
(B) 97^{o}C

(C) 125^{o}C

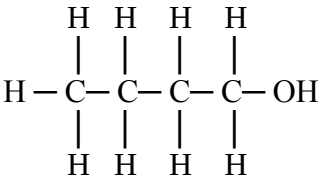
(D) 145^{o}C

8. Which of the following is an isomer of 1-butanol?

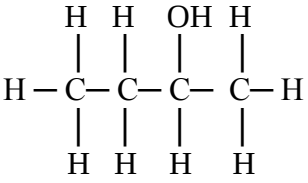
(A)



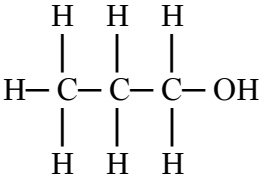
(B)



(C)



(D)



9. When hydrochloric acid is added to aluminium sulfide, the highly toxic gas hydrogen sulfide is evolved. The equation for this reaction is

$$Al_2S_3(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2S(g)$$

If excess hydrochloric acid is added to 0.200 mol of aluminium sulfide, what will be the volume of hydrogen sulfide gas produced at 25°C?

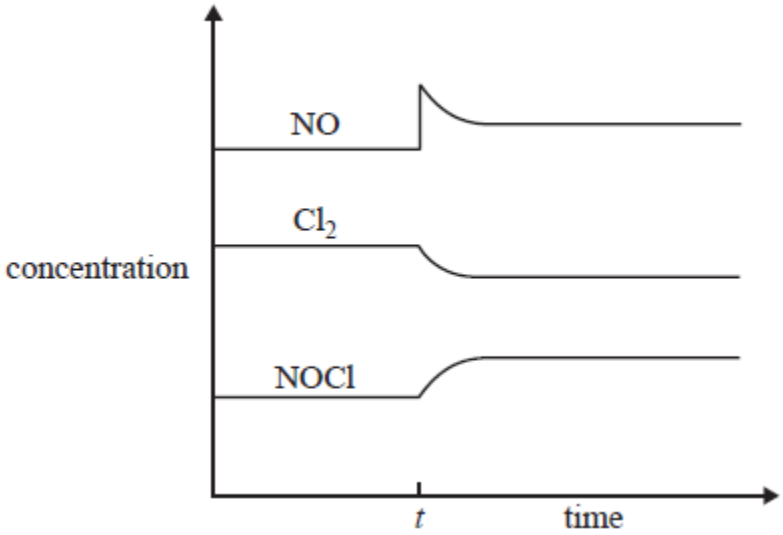
(A) 1.63 L

(B) 4.90 L

(C) 7.35 L

(D) 14.7 L

10. A concentration–time graph for an equilibrium is shown below.



What event occurred at time *t* to cause the change in equilibrium concentrations?

(A) The pressure was decreased at a constant temperature.

(B) The temperature was increased at a constant volume.

(C) A catalyst was added at a constant temperature and volume.

(D) Additional NO gas was added at a constant volume and temperature.

11. Identify the amphiprotic substances in the following equilibrium equations.

$H_2CO_3(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$

W **X** **Y** **Z**

$HCO_3^-(aq) + OH^-(aq) \rightleftharpoons CO_3^{2-}(aq) + H_2O(l)$

P **Q** **R** **S**

(A) Y, P

(B) Y, Z, P, R

(C) Y, P, X, S

(D) W, Y, P, R

12 Which of the following statements must be true to ensure an acid-base titration is valid?

(A) The burette reading starts at 0 mL.

(B) An appropriate indicator is added into the conical flask.

(C) Initially there is exactly 25 mL of solution in the conical flask.

(D) A sheet of white paper is placed below the conical flask.

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 (6 marks) **Marks**

(a) 0.01 mol L^{-1} solutions of citric acid and acetic acid were prepared and the pH of each of these solutions was measured. It was found that acetic acid had a higher pH.

Which is the stronger acid, citric or acetic? Explain your answer. **2**

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(b) Calculate the pH of the final solution after mixing 50.0 mL of 0.10 $molL^{-1}$ nitric acid and 25.0 mL of 0.10 $molL^{-1}$ sodium hydroxide solution. **4**

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Question 14 (6 marks)

Chemists in the food industry seek to artificially prepare the active ingredient for food flavourings. Esters are frequently used for this purpose.

(a) Write the equation for the formation of the ester formed from the reaction of methanol and butanoic acid using structural formulas. **3**

(b) Name the ester formed. **1**

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(c) The ester formed in part (a) has to be distilled in order to isolate it as a pure substance. How would you confirm its purity? **1**

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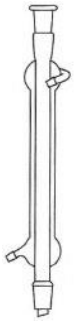
(d) Identify this specialised piece of equipment used in the preparation of an ester. **1**



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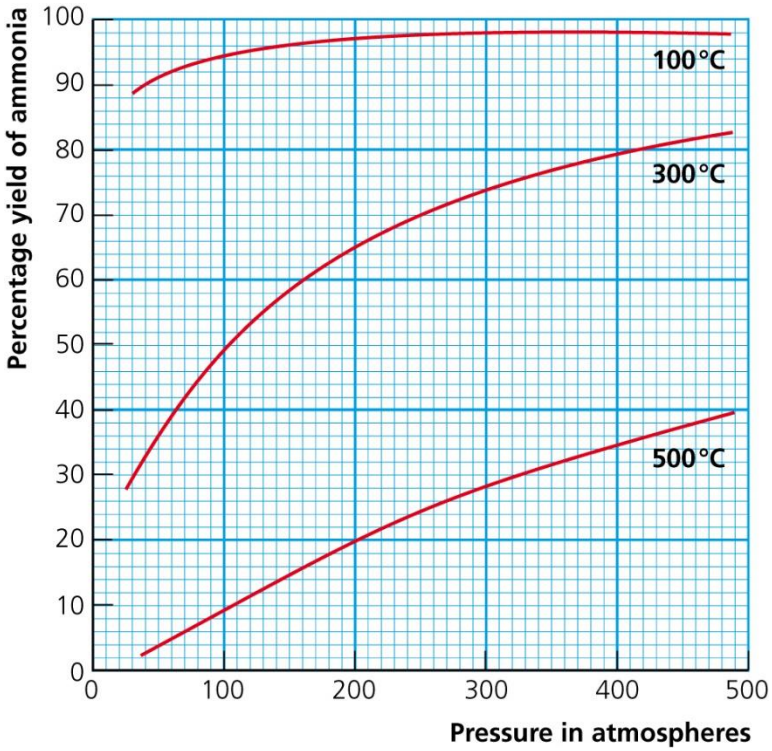
Question 15 (9 marks)

Nitrogen and hydrogen are reacted together in the Haber process to make ammonia.

The graph shows how the percentage yield of ammonia depends on the temperature and pressure inside the reaction vessel.



(a) Explain the effect of increasing the pressure in this reaction. **4**

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(b) Identify the percentage yield of ammonia produced at a temperature of 300°C and a pressure of 100 atmospheres. **1**

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(c) Identify the conditions of temperature and pressure used in industry and explain why the conditions which give the maximum yield of ammonia are not used. **4**

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Question 16 (4 marks)

Incomplete combustion of petrol (which can be considered to be mainly octane, C_8H_{18}) produces significant pollutants.

(a) Construct a balanced equation for the incomplete combustion of octane. **2**

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(b) Outline a consequence of an identified pollutant in this reaction. **2**

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Question 17 (2 marks)

All aqueous solutions of sodium cyanide (NaCN) are basic.

Explain this statement with the support of an appropriate equation. **2**

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Question 18 (2 marks)

Indicators are useful in obtaining an approximate pH range of solutions.

The table gives the colour change and transition pH of indicators P, Q, R and S.

It also gives the colour obtained when 1.0 mL of a colourless sample, X ,is mixed with 1 drop of the indicator.

Indicator	Colour change	Transition pH	Colour of sample X
P	orange – red	2.2 - 3.6	red
Q	yellow – purple	5.2 – 6.8	yellow
R	yellow - red	6.4 – 8.0	yellow
S	colourless - blue	8.3 – 10.5	colourless

(a) What is the pH range for sample X? **1**

……..**.....**

(b) What could be used to determine an exact measure of the pH of sample X? **1**

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Question 19 (2 marks)

Muriatic acid (HCl), analysed by Humphry Davy, was shown to contain hydrogen and chlorine.

Explain why Lavoisier would not have classified HCl as an acid but Arrhenius would. **2**

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End of Theory Test

Part B extra writing space

If you use this space, clearly indicate which question you are answering.

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2016 HSC Chemistry Term 1 Theory Answers

Part A: Answer grid for multiple choice questions.

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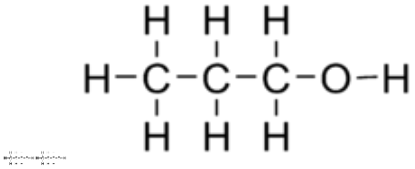
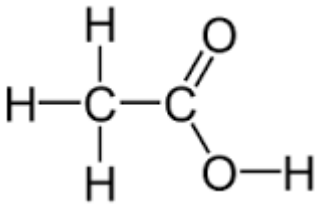
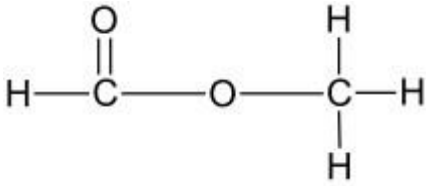
X		60	?
Y		60	117
Z		60	32

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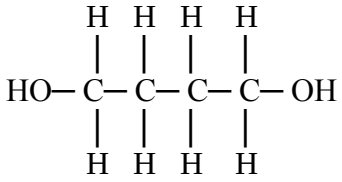

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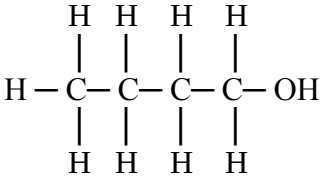
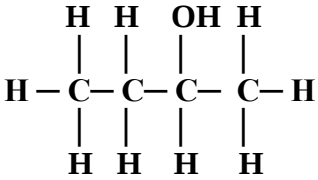
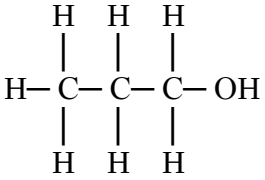


(C)



(D)



9. When hydrochloric acid is added to aluminium sulfide, the highly toxic gas hydrogen sulfide is evolved. The equation for this reaction is

$$Al_2S_3(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2S(g)$$

If excess hydrochloric acid is added to 0.200 mol of aluminium sulfide, what will be the volume of hydrogen sulphide produced at 25°C?

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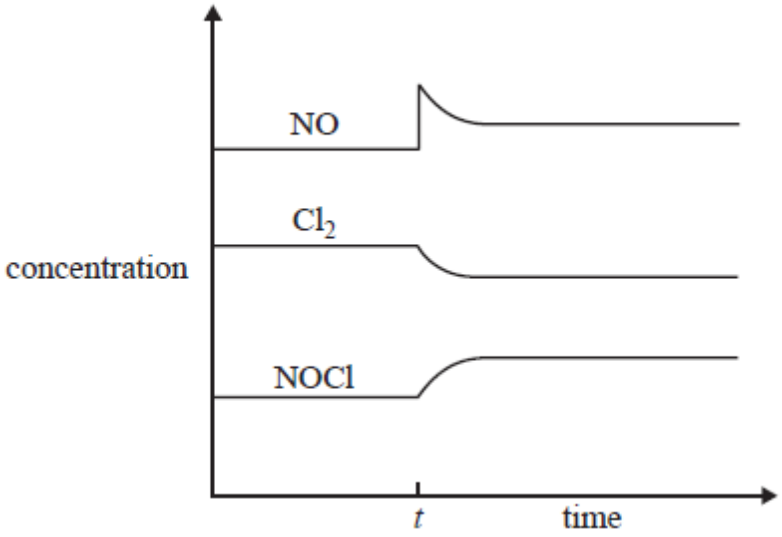
10. A concentration–time graph for an equilibrium is shown below.



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11. Identify the amphiprotic substances in the following equilibrium equations.

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W **X** **Y** **Z**

$HCO_3^-(aq) + OH^-(aq) \rightleftharpoons CO_3^{2-}(aq) + H_2O(l)$

P **Q** **R** **S**

(A) Y, P

(B) Y, Z, P, R

(C) Y, P, X, S

(D) W, Y, P, R

12 Which of the following statements must be true to ensure an acid-base titration is valid?

(A) The burette reading starts at 0 mL.

(B) An appropriate indicator is added into the conical flask.

(C) Initially there is exactly 25 mL of solution in the conical flask.

(D) A sheet of white paper is placed below the conical flask.

Part B 30 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**

(a) 0.01 mol L^{-1} solutions of citric acid and acetic acid were prepared and the pH of each of these solutions was measured. It was found that acetic acid had a higher pH.

Which is the stronger acid, citric or acetic? Explain your answer. **2**

Sample Answer : Citric acid is the stronger acid since its pH is lower thus it has more $[H^+]$. Citric acid has a higher degree of ionisation than ethanoic acid.

Criteria	Marks
Correct choice of stronger acid and explanation	2
Correct choice of acid	1

(b) Calculate the pH of the final solution after mixing 50.0 mL of 0.10 $molL^{-1}$ nitric acid and 25.0 mL of 0.10 $molL^{-1}$ sodium hydroxide solution. **4**

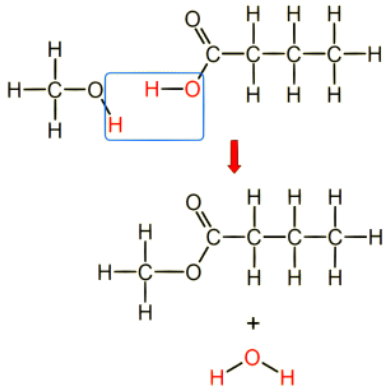
Sample Answer :
Eqn = HNO_3 + $NaOH$ --→ $NaNO_3$ + H_2O
$n(HNO_3) = 50/1000 \times 0.10 = 5.0 \times 10^{-3}$ mol
$n(KOH) = 25.00/1000 \times 0.10 = 2.5 \times 10^{-3}$
Limiting reagent is KOH at 2.5×10^{-3} mol
Thus $n(HNO_3)$ left over = $5.00 \times 10^{-3} - 2.50 \times 10^{-3} = 2.5 \times 10^{-3}$ mol
Total volume = 50.00 mL + 25.00 mL = 75.00 mL = 0.075 L
Final solution has HNO_3 remaining.
Concentration of HNO_3 = $2.5 \times 10^{-3} / 0.075$ L = 0.033 $molL^{-1}$
HNO_3 is a strong acid thus complete ionisation.
$[H_3O^+]$ = 0.033 $molL^{-1}$ pH = $-\log_{10}[H_3O^+] = -\log_{10}(0.033) = 1.48$, thus pH = 1.48

Criteria	Marks
Correct calculations of solution in excess and final pH	4
One error in calculation	3
Two errors in calculation	2
Three errors in calculation	1

Question 14 (2 marks)

Chemists in the food industry seek to artificially prepare the active ingredient for food flavourings. Esters are frequently used for this purpose.

(a) Write the equation for the formation of the ester formed from the reaction of methanol and butanoic acid using structural formulas. **3**



Marking Criteria	Marks
Correct structural formula for all reactants and products	3
One error in structure	2
Two errors in structure	1

(b) Name the ester formed. **1**

Sample Answer : Methyl butanoate

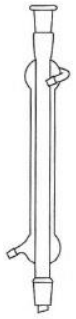
Marking Criteria	Marks
Correct answer	1

(c) The ester formed in part (a) has to be distilled in order to isolate it as a pure substance. How would you confirm its purity? **1**

Sample Answer ; Test boiling point and compare with value in Data Book

Marking Criteria	Mark
Correct description of test	1

(d) Identify this specialised piece of equipment used in the preparation of an ester. **1**



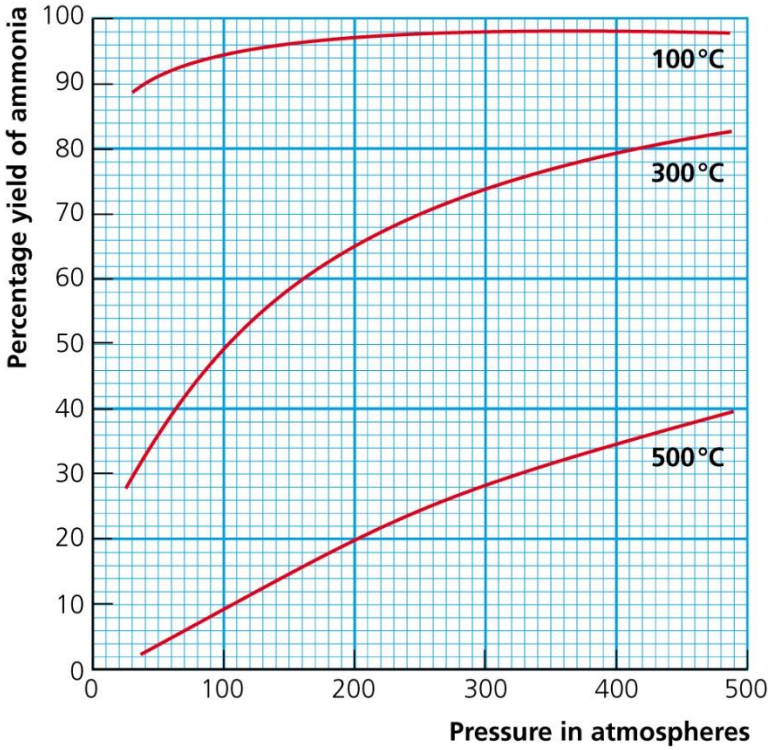
Sample Answer : Reflux condenser or condenser

MarkingCriteria	Marks
Correct identification of the apparatus	1

Question 15 (7 marks)

Nitrogen and hydrogen are reacted together in the Haber process to make ammonia.

The graph shows how the percentage yield of ammonia depends on the temperature and pressure inside the reaction vessel.



(a) Explain the effect of increasing the pressure in this reaction. **4**

Sample answer

$3H_2\,(g) + N_2\,(g) \rightleftarrows 2NH_3\,(g) + heat$

This is an equilibrium and when a change is made to the conditions, the equilibrium will shift to oppose the change (Le Chatelier). An increase in pressure will shift the equilibrium to the side that reduces the pressure i.e. the side with fewer gas molecules. This is the forward reaction (4:2)
Equilibrium will shift right and favour the formation of ammonia, NH_3.

Marking Criteria	*Mark(s)*
• *Thoroughly explains the shift in equilibrium using Le Chatelier's principle, giving the molar gas ratio.* • *Includes a balanced equation with equilibrium arrows*	*4*
• *Thoroughly explains the shift in equilibrium using Le Chatelier's principle OR gives the molar gas ratio* • *Includes an equation with or without equilibrium arrows or unbalanced*	*3*
• *Outlines the shift in equilibrium*	*2*
• *Gives an equation OR* • *Identifies some features of the effect of pressure*	*1*

(b) Identify the percentage yield of ammonia produced at a temperature of 300°C and a pressure of 100 atmospheres. **1**

Percentage yield = 48% or 49%

CRITERIA	**MARK**
Calculate the correct percentage yield from the graph supplied	1

(c) Identify the conditions of temperature and pressure used in industry and explain why the conditions which give the maximum yield of ammonia are not used. **4**

The conditions used in industry are
Temperature 450 – 550 ^oC (400-550)
Pressure 250 atm (200 – 350)

*The conditions that give maximum yield of ammonia on the graph are **100^oC and 490 atm**.*
The cost of manufacturing the equipment to withstand very high pressures is too great/very high pressure increases the risk to safety.

The reaction is too slow at low temperatures.

*The idea of a **compromise** between yield and rate/cost will score 1 mark.*

Full marks require a more specific answer relating to both temperature and pressure.

Marking Criteria	*Mark(s)*
• *Identifies industrial conditions* • *Identifies conditions for maximum yield* • *Gives reasons why the maximum yield conditions (both) are not used*	*4*
• *Gives reasons why the maximum yield conditions are not used* • *Identifies industrial conditions OR* • *Identifies conditions for maximum yield*	*3*
• *Outlines the conditions used and the reasons for not using the conditions for maximum yield*	*2*
• *Gives some information on the conditions*	*1*

Question 16 (3 marks)

Incomplete combustion of petrol (which can be considered to be mainly octane, C_8H_{18}) produces significant pollutants.

(a) Construct a balanced equation for the incomplete combustion of octane **2**

$C_8H_{18}(l) + 8O_2(g) \rightarrow 7CO(g) + C(s) + 9H_2O(l)$

CRITERIA	**MARKS**
A correct balanced equation with states	2

(b) Outline a consequence of an identified pollutant in this reaction. **2**

Carbon is a particulate pollutant in air that can cause reduced visibility and respiratory irritation

CRITERIA	**MARKS**
Outlines a consequence of a named pollutant	**2**
Identifies a pollutant	**1**

Question 17 (2 marks)

All aqueous solutions of sodium cyanide (NaCN) are basic.

Explain this statement with the support of an appropriate equation. **2**

SAMPLE ANSWER:
$CN^-(aq) + H_2O(l) \rightleftarrows HCN(aq) + OH^{-1}(aq)$

HCN is a weak acid and only partially ionises, whilst NaOH is a strong base. This means the NaOH will completely ionise in an aqueous solution and produce excess OH- ions raising the pH of the solution and making it basic.

CRITERIA	**MARKS**
Explains that NaCN hydrolyses in water to produce an OH^- that raises the pH. OR states that NaCN behaves as a proton acceptor AND Provides an equation for the hydrolysis of NaCN	2
Explains NaCN releases OH- increases the pH making the solution basic OR Provides an equation for the hydrolysis of NaCN	1

Question 18 (2 marks)

Indicators are useful in obtaining an approximate pH range of solutions.

The table gives the colour change and transition pH of indicators P, Q, R and S.

It also gives the colour obtained when 1.0 mL of a colourless sample X is mixed with 1 drop of the indicator.

Indicator	Colour change	Transition pH	Colour of sample X
P	orange – red	2.2 - 3.6	red
Q	yellow – purple	5.2 – 6.8	yellow
R	yellow - red	6.4 – 8.0	yellow
S	colourless - blue	8.3 – 10.5	colourless

(a) What is the pH range for sample X? **1**

Between 3.6 and 5.2

(b) What could be used to determine an exact measure of the pH of sample X? **1**

A pH meter

Question 19 (2 marks)

Muriatic acid (HCl), analysed by Humphry Davy, was shown to contain hydrogen and chlorine.

Explain why Lavoisier would not have classified HCl as an acid but Arrhenius would. **2**

Sample answer

Lavoisier believed that acids were made up of at least two substances, one of which was oxygen, therefore Lavoisier wouldn't have classified HCl as an acid.
Arrhenius classified acids as creating hydrogen ions in water. HCl ionizes in water to produce hydrogen ions (hydronium ions) and is therefore an Arrhenius acid.

Marking Criteria	*Mark(s)*
• *Correctly explains the nature of HCl for both Lavoisier and Arrhenius*	*2*
• *Outlines the nature of HCl for Lavoisier or Arrhenius*	*1*