Chemistry Assessment

Task 2 Term 1 2012

Theory

**Acidic Environment
& Chemical Monitoring**

General Instructions

- **Reading time – 5 minutes**
- **Working time – 55 minutes**
- **Write using black or blue pen**
- **Write your Student Number at the top of this page and on pages 8 and 9.**
- **Board-approved calculators may be used**

  A data sheet and a periodic table are provided

Total Marks –   54

Part A – 14 marks

- Attempt Questions 1 – 14
- Allow about 15 minutes for this part

Part B – 40 marks

- Attempt Questions 15 - 23
- Allow about 40 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.
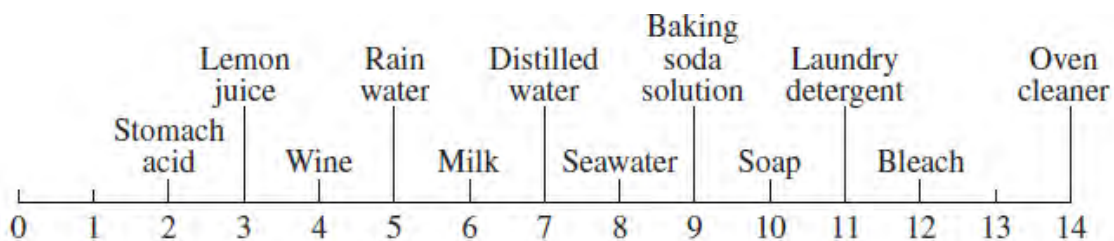
correct

A ✖   B ✖   C ◯   D ◯

▸ **Mark your answers for the multiple choice questions in the multiple choice grid on page 8**

Multiple Choice (*Mark your answers on the multiple choice grid on page 8*)

1.   Which statement best represents Lavoisier's definition of an acid?

   (A)   Acids contain oxygen.

   (B)   Acids are proton donors

.

   (C)   Acids contain replaceable hydrogen.

   (D)   Acids ionise in solution to form hydrogen ions.

2.   Nitrogen gas inflates a car's airbag on impact according to the following decomposition of sodium azide.

   $2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$

   What mass of sodium azide will produce 60.0 L of N_2 at 100 kPa and $0^{o}C$?

   (A)   258 g

   (B)   171 g

   (C)   114 g

   (D)   105 g

3.   Which of the following species is amphiprotic?

   (A) SO_4^{2-}

   (B) HCO_3^{-}

   (C) NH_4^{+}

   (D) H_2SO_4

4. The figure shows the pH values of some substances.

Based on the pH values shown in the figure, which of the following statements about the concentration of hydrogen ions is correct?
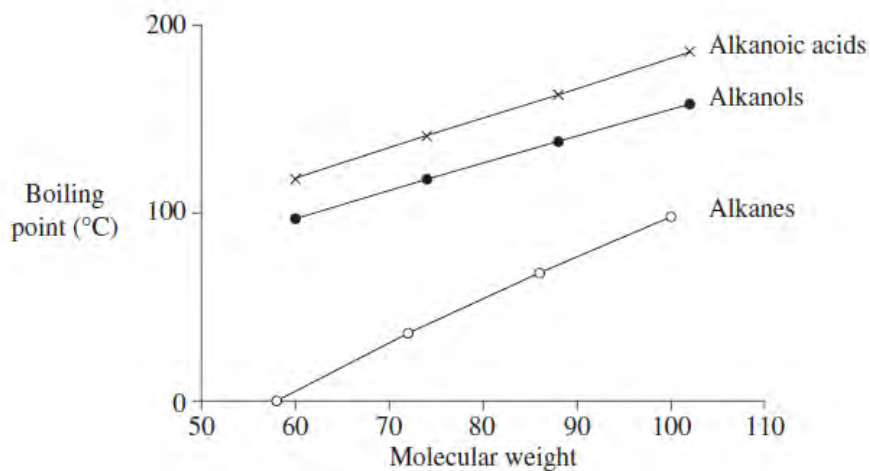
(A)   It is twice as great in seawater as that in wine.

(B)   It is 1000 times greater in milk than in lemon juice.

(C)   It is 100 times greater in distilled water than in baking soda solution.

(D)   It is twice as great in rainwater as it is in soap.

5. The following equilibrium exists in a can of carbonated drink.

$$CO_2(g) \; + \; H_2O(l) \; \rightleftharpoons \; H_2CO_3(aq)$$

Which of the following conditions will cause the drink to go 'flat'?

(A)   Reduction in temperature.

(B)   Reduction in pressure.

(C)   Addition of water.

(D)   Increase in pressure.

6. Which of the following would not be an example of a buffer solution?

(A) HCl / Cl^-

(B) $H_2PO_4^- / HPO_4^{2-}$

(C) HCO_3^- / CO_3^{2-}

(D) CH_3COO^- / CH_3COOH

7. Which of the following statements is incorrect concerning trends in the graph?

(A) Alkanoic acids have higher boiling points than the corresponding alkanols because they have more extensive hydrogen bonding.

(B) Alkanes only have weak hydrogen bonding so their boiling points are the lowest.

(C) Alkanols have hydrogen bonding and have higher boiling points than the corresponding alkanes.

(D) As molar mass increases, boiling point increases.

8. On this periodic table, which of these elements would form the most acidic oxide?

(A) Q

(B) R

(C) S

(D) T

9.   In which of the following alternatives are the three compounds listed in order of increasing boiling point?

(A)   Propanoic acid, butan-1-ol, pentane

(B)   Propanoic acid, pentane, butan-1-ol

(C)   Butan-1-ol, propanoic acid, pentane

(D)   Pentane, butan-1-ol, propanoic acid

10.   What is the IUPAC name for the following compound?
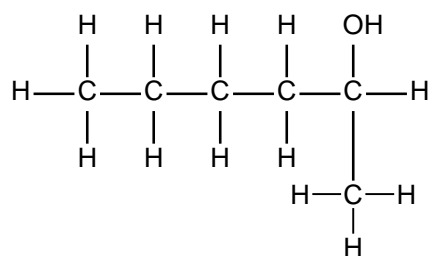
(A)   Hexan–1–ol

(B)   1–methylpentan–2–ol

(C)   Hexan–2–ol

(D)   Pentan–2–ol

11.   Consider the following reaction at equilibrium

$$N_2(g) \; + \; 3H_2(g) \; \rightleftharpoons \; 2NH_3(g) \qquad \Delta H = \text{- } 92 \text{ kJmol}^{-1}$$

What would be the effect of an increase in pressure on this system?

(A)   The equilibrium will not be disturbed.

(B)   More heat will be produced.

(C)   The equilibrium will shift to the left.

(D)   Heat will be absorbed.

12. Which of the following reactions occur in esterification?

(A)   Organic acid reacts with alcohol.

(B)   Organic acid reacts with an ester.

(C)   Organic acid reacts with a base.

(D)   Organic acid reacts with an active metal.

13.   Which chemist is attributed with the method for synthesizing ammonia from its elements?

(A)   Carl Bosch

(B)   Fritz Haber

(C)   Antoine Lavoisier

(D)   Humphry Davy

14.   Which statement best explains why oxygen needs to be removed when ammonia is manufactured?

(A)   Oxygen reacts with nitrogen to form nitrous oxides.

(B)   Oxygen interferes with the catalyst used in the process.

(C)   Oxygen can react with hydrogen in the process.

(D)   Oxygen reacts with the ammonia in the process.

Test continues next page...

Part A . Answer grid for multiple choice questions   Total ....

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

13.   A O   B O   C O   D O

14.   A O   B O   C O   D O

Total ....

Part B: Free Response Questions: (38 marks)

Attempt Questions 15 –23. Allow about 40 minutes for this part.
‣ *Show all relevant working in questions involving calculations.*

Marks

Question 15 (6 marks)

Sulfur dioxide is a pollutant gas in the atmosphere.
Evaluate reasons for concern about the release of sulfur dioxide from industrial origins into the
environment. Include relevant equations in your answer.

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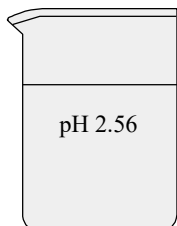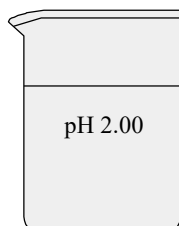
Question 16 (4 marks)

(a)   Explain the difference in pH between the two acids in the diagram.   **2**

0.01 M
acetic acid

0.01 M
hydrochloric acid

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(b)   Calculate the pH of a solution prepared when 60 mL of 0.10 $molL^{-1}$ hydrochloric acid solution
is diluted with 190 mL of water.   **2**

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Question 17 (5 marks)

Sodium hydrogen carbonate is a very useful salt.

(a) Write a net ionic equation to show the behaviour of sodium hydrogen carbonate in water and identify it as an acidic, basic or neutral salt. **2**

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(b) Identify a conjugate acid/base pair in the equation in (a). **1**

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(c) Sodium hydrogen carbonate can be used to make a primary standard for titrations.

Calculate the mass of sodium hydrogen carbonate required to prepare 250 mL of a 0.200 molL^{-1} solution. **2**

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Question 18 (4 marks)
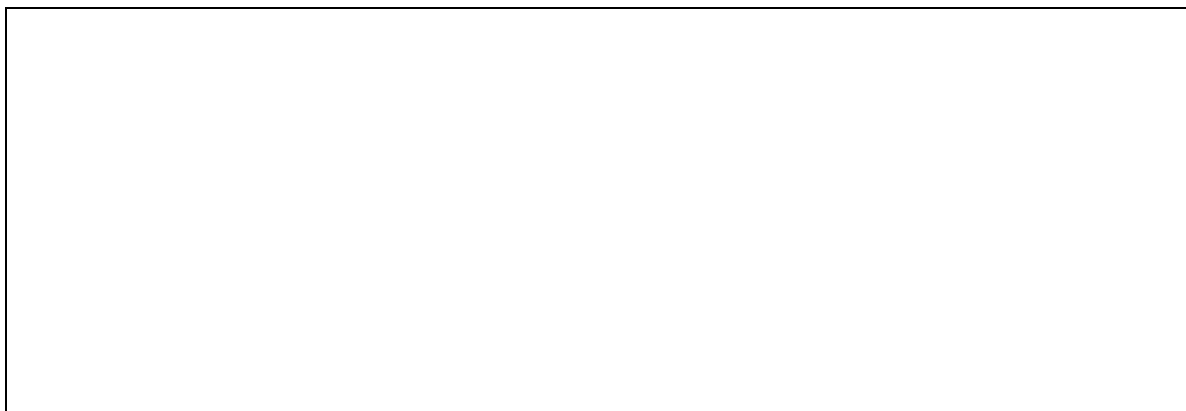
Discuss two factors that must be considered when using neutralization reactions to safely minimize damage in chemical spills. **4**

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Question 19 (2 marks)

Draw the structure for citric acid and give its systematic name.   **2**

Question 20 (4 marks)

A gas is produced when 10.6 g of sodium carbonate is placed in 50.0 mL of 1.00 molL^{-1} hydrochloric acid.

Calculate the volume of gas produced at 25°C and 100 kPa. Include a balanced equation in your answer.   **4**

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Question 21 (4 marks)

Combustion reactions are important in industry and for society. Scientists must monitor and manage combustion reactions.

(a)   Write an equation for the incomplete combustion of octane, C_8H_{18}.   **1**

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(b)   Justify the need for the monitoring and management of combustion reactions.   **3**

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Question 22 (5 marks)

The graphs below show the fraction of ammonia present at equilibrium when nitrogen and hydrogen react under varying conditions of temperature and pressure.
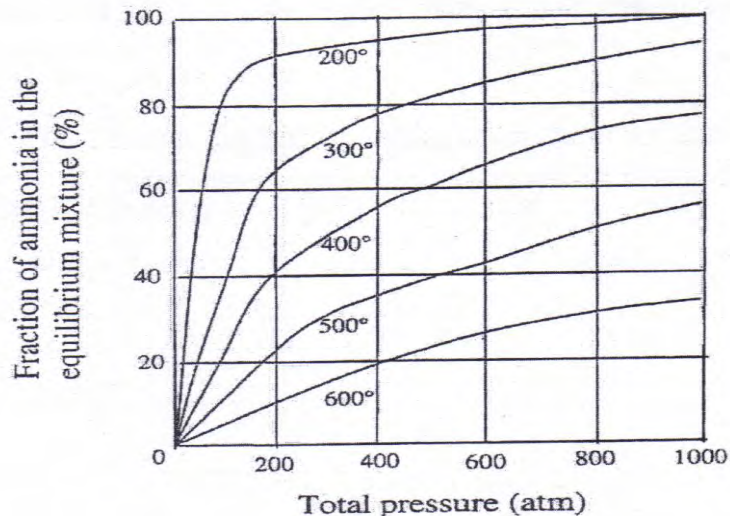
(a)   Use the information from the graphs to identify the conditions of temperature and pressure which would give the highest yield of ammonia.   **1**

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(b)   Explain why the Haber process is carried out industrially under compromise conditions of both temperature and pressure.   **2**

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Question 22 continues next page

(c)   Magnetite is the catalyst used for this process. Explain the impact of the catalyst on the rate
       and/or yield of this industrial process.   **2**

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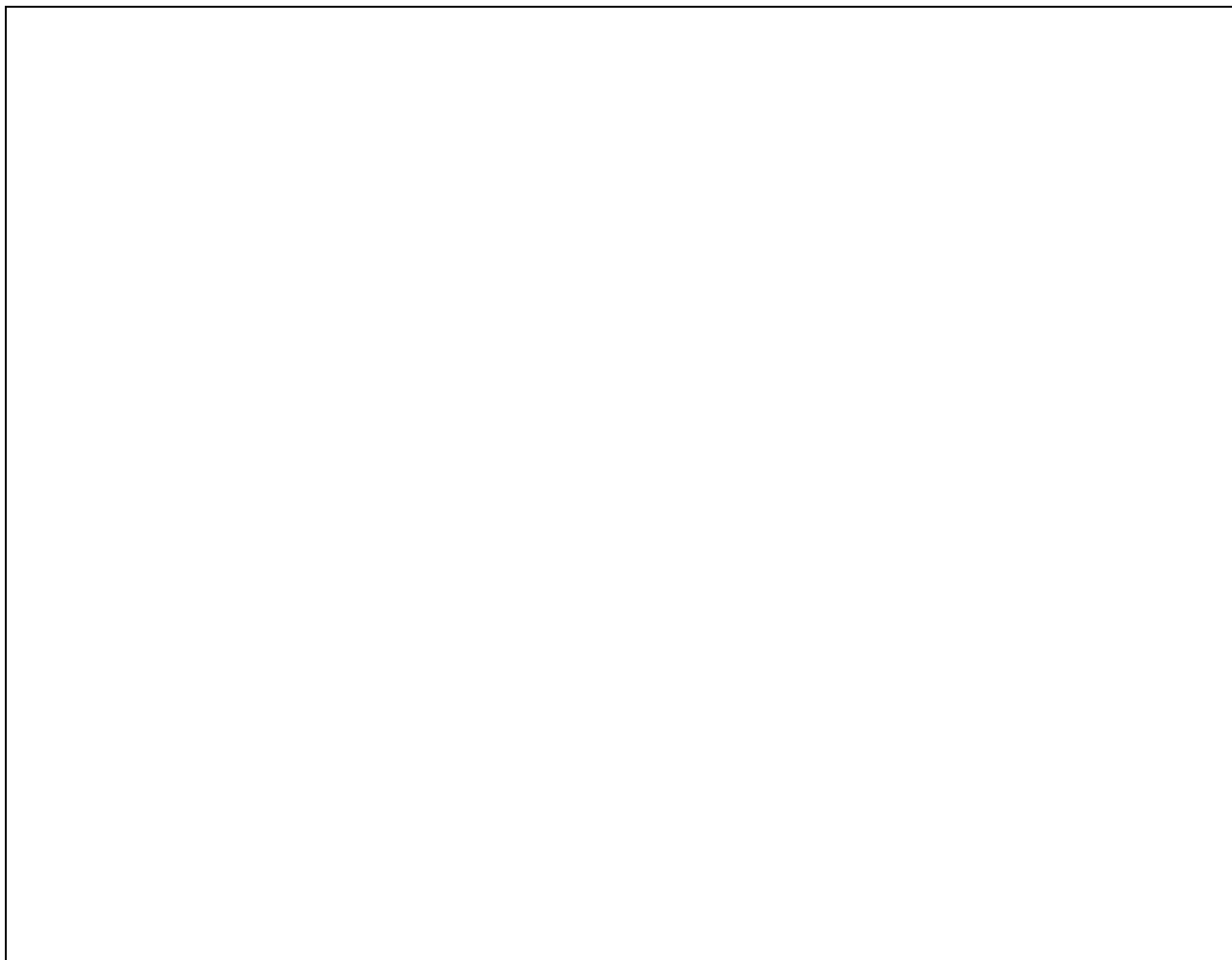
Question 23 (4 marks)

Draw and label a scientific diagram of the apparatus used in the process of esterification   **4**

☙ *END of Theory Test*

Chemistry Assessment

Task 2 Term 1 2012

Theory

Acidic Environment
& Chemical Monitoring

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Total Marks – 54

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

A ○   B ●   C ○   D ○

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correct

A ✖   B ✖   C ○   D ○

▶ **Mark your answers for the multiple choice questions in the multiple choice grid on page 8**

1. Which statement best represents Lavoisier's definition of an acid?

   (A) Acids contain oxygen.
   (B) Acids are proton donors.
   (C) Acids contain replaceable hydrogen.
   (D) Acids ionise in solution to form hydrogen ions.

   Outcomes:H1.H2

2. Nitrogen gas inflates a car's airbag on impact according to the following decomposition of sodium azide.
   $$2NaN_3 (s) \rightarrow 2Na (s) + 3N_2 (g)$$

   What mass of sodium azide will produce 60.0L of N_2 at 100 kPa and 0^0C?

   (A) 258 g
   (B) 171 g
   (C) 114 g
   (D) 105 g

   Outcomes:H10,H4

3. Which of the following species is amphiprotic?

   (A) SO_4^{2-}
   (B) HCO_3^-
   (C) NH_4^+
   (D) H_2SO_4

   Outcomes:H8

4. The figure shows the pH values of some substances
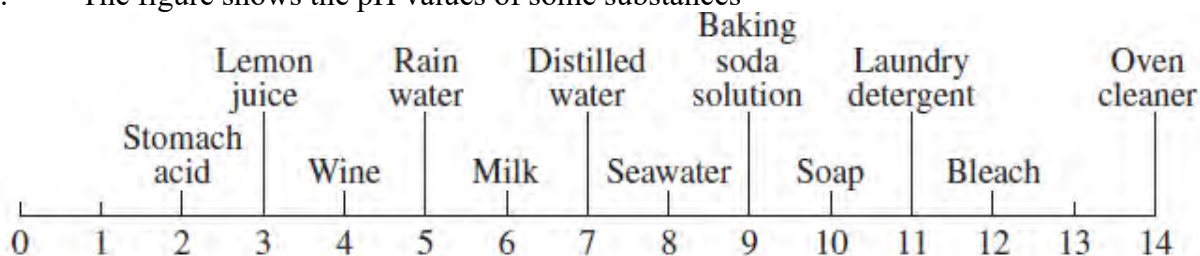
   Based on the pH values shown in the figure, which of the following statements about the concentration of hydrogen ions is correct?

   (A) It is twice as great in seawater as that in wine.
   (B) It is 1000 times greater in milk than in lemon juice.
   (C) It is 100 times greater in distilled water than in baking soda solution.
   (D) It is twice as great in rainwater as it is in soap.

   Outcomes:H8

5.   The following equilibrium exists in a can of carbonated drink.
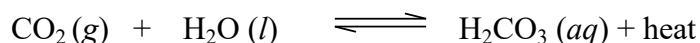
$$CO_2 (g) \ + \ H_2O \ (l) \ \rightleftharpoons \ H_2CO_3 \ (aq) + heat$$

Which of the following conditions will cause the drink to go "flat"?

(A)   Reduction in temperature.
(B)   Reduction in pressure.
(C)   Addition of water.
(D)   Increase in pressure.

Outcomes:H8

6.   Which of the following would not be an example of a buffer solution?
(A)   HCl /Cl⁻
(B) $H_2PO_4^-/HPO_4^{2-}$
(C) HCO_3^-/CO_3^{2-}
(D) CH_3COO^-/CH_3COOH

Outcomes:H8,H9

7.   Which of the following statements is incorrect concerning trends in the graph?
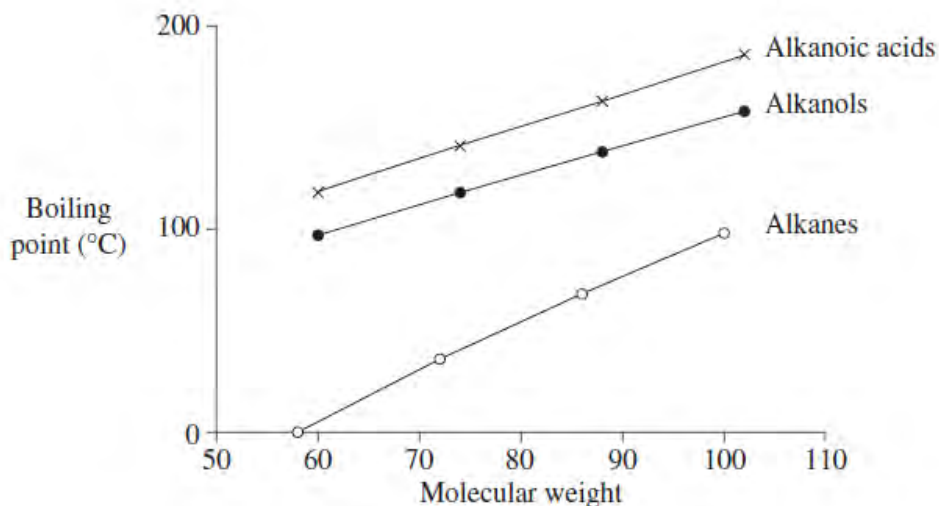
(A)   Alkanoic acids have higher boiling points than the corresponding alkanols because they have more extensive hydrogen bonding.
(B)   Alkanes only have weak hydrogen bonding so their boiling points are the lowest.
(C)   Alkanols have hydrogen bonding and have higher boiling points than the corresponding alkanes.
(D)   As molar mass increases, boiling point increases.

Outcomes:H9,H6

8. On this periodic table, which of these elements would form the most acidic oxide?

I	II	III	IV	V	VI	VII	VIII
		R					T
					S		
Q							

(A) Q
(B) R
(C) S
(D) T

Outcomes:H6

9. In which of the following alternatives are the three compounds listed in order of increasing boiling point?

(A) Propanoic acid, butan-1-ol, pentane
(B) Propanoic acid, pentane, butan-1-ol
(C) Butan-1-ol, propanoic acid, pentane
(D) Pentane, butan-1-ol, propanoic acid

Outcomes:H8, H9

10. Which is the IUPAC name for the following compound?
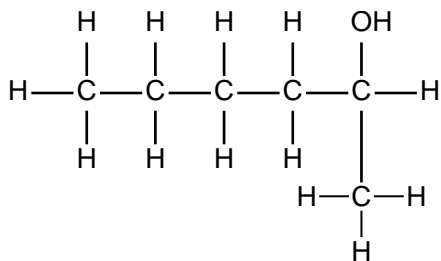
(A) Hexan – 1 – ol

(B) 1-methylpentan- 2- ol

(C) Hexan – 2 – ol

(D) Pentan – 2 – ol

Outcomes: H9

11. Consider the following reaction at equilibrium

$$N_2(g) \ + \ 3H_2(g) \ \rightleftharpoons \ 2NH_3(g) \qquad \triangle H = -92 \text{ kJmol}^{-1}$$

What would be the effect of an increase in pressure on this system?

(A) The equilibrium will not be disturbed
(B) More heat will be produced
(C) The reverse reaction will decrease
(D) Heat will be absorbed

Outcomes: H8, H10

12. Which of the following reaction occurs in the process of esterification?

(A) Organic acid reacts with alcohol
(B) Organic acid reacts with an ester
(C) Organic acid reacts with a base
(D) Organic acid reacts with an active metal

Outcomes: H9

13. Which chemist is attributed with the method for synthesizing ammonia from its elements?
(A) Carl Bosch
(B) Fritz Haber
(C) Antoine Lavoisier
(D) Humphry Davy

Outcome: H4

14. Which statement best explains why oxygen needs to be removed from the process to produce ammonia?

(A) Oxygen reacts with nitrogen to form nitrous oxides.

(B) Oxygen interferes with the catalyst used in the process.

(C) Oxygen can react with hydrogen in the process.

(D) Oxygen reacts with the ammonia in the process.

Outcomes: H6, H10

Part A . Answer grid for multiple choice questions   **Total**

1.   A ●   B O   C O   D O

2.   A O   B O   C ●   D O

3.   A O   B ●   C O   D O

4.   A O   B O   C ●   D O

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 ●   D O

9.   A O   B O   C O   D ●

10.   A O   B O   C ●   D O

11.   A O   B ●   C O   D O

12.   A ●   B O   C O   D O

13.   A O   B ●   C O   D O

14.   A O   B O   C ●   D O

Total ....

Question 15 (6 marks)

Sulfur dioxide is a pollutant gas in the atmosphere.
Evaluate reasons for concern about the release of sulfur dioxide from industrial origins into the environment. Include relevant equations in your answer.

Sample answer

Sulfur dioxide can be released in to the environment when smelting metal ores

$ZnS + 3/2\ O_2 \rightarrow ZnO + SO_2$
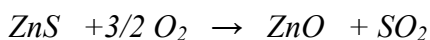
Two reasons for concern are that sulfur dioxide can combine with water to cause acid rain in the atmosphere or acidify waterways if bubbled through water. These acid solutions can cause exfoliation of flora and create acidic environments in which aquatic organisms can die.

Acid rain : $SO_2 + H_2O \rightarrow H_2SO_3$
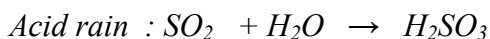
Sulfur dioxide in air can also cause respiratory problems if breathed in.

Evaluation : There is a deep need for concern when SO_2 levels increase in the environment.
SO_2 can be damaging to organisms and infrastructure when it combines with water. The implications of SO_2 in the environment are severe and measures like treating flue gases have been taken to reduce its presence in the environment.

Outcomes:H4

Marking criteria	Marks
• *Cites an industrial origin of SO_2* • *Two relevant equations* • *Two reasons for concern* • *Evaluation of those reasons*	6
• *4 of the above, must have evaluation*	5
• *At least 4 of the above, no evaluation*	4
• *At least 3 of the above, no evaluation*	3
• *At least 2 of the above, no evaluation*	2
• *At least 1 of the above, no evaluation*	1

Question 16 (4 marks)

(a)   Explain the difference in pH between the two acids in the diagram. (2 marks)

pH 2.56

pH 2.00

0.01 M
acetic acid

0.01 M
hydrochloric acid
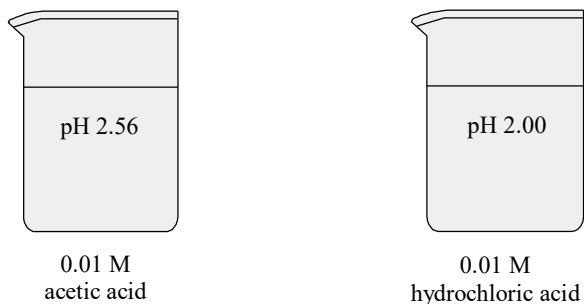
Sample answer

Acetic acid is a weak acid that only partially ionizes in water, there are fewer H ions and therefore the pH is greater than hydrochloric acid that completely ionizes in water. With more hydrogen ions the pH of hydrochloric acid is lower.

Marking criteria	*Marks*
• *Explains the difference in pH fully*	*2*
• *Outlines the difference OR only explains the pH of one solution*	*1*

(b)   Calculate the pH of a solution prepared when 60 mL of 0.10molL^{-1} hydrochloric acid solution is diluted with 190 mL of water.(2 marks)

Sample answer

c1v1 = c2v2   *pH = -log[H$^+$]*
60 x 0.1 = 250 x X   *= 1.62(1 mark)*
X = 0.024 (1 mark)
Outcomes:H8,H6

Question 17 (5 marks)

Sodium hydrogen carbonate is a very useful salt.

(a)   Write a net ionic equation to show the behaviour of sodium hydrogen carbonate in water and identify it as an acidic, basic or neutral salt. (2 marks)
         HCO_3^- + H_2O ⇌ H_2CO_3 + OH^- (1 mark)   *basic salt (1 mark)*
(b)   Identify a conjugate acid/base pair in (a). (1 mark)
         HCO_3^- / H_2CO_3
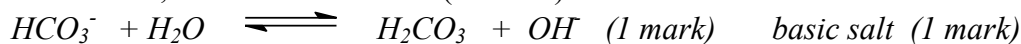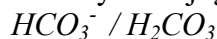
(c)   Sodium hydrogen carbonate can be used to make a primary standard for titrations.
Calculate the mass of sodium hydrogen carbonate required to prepare 250 mL of a 0.200 $molL^{-1}$ solution. (2 marks)

Sample answer
Mol NaHCO₃ = M x V   mass NaHCO₃ = mol x molar mass
*   = 0.200 x 0.250   =0.0500 x[22.99 + 1 + 12 + 3(16)]*
*   =0.0500(1 mark)   = 4.20g(1 mark)*

Outcomes:H8,H10

Question 18 (4 marks)

Discuss two factors that must be considered when using neutralization reactions to safely minimize damage in chemical spills.

Sample answer

The nature of the spill and the location of the spill. If it is a large acid spill in the environment then a carbonate may be used to neutralize the spill effectively and the cleanup can be safely achieved. An acid spill on the skin, however cannot be neutralized with base as the reaction is exothermic and will only contribute to the damage, in this case the spill needs to be washed away with lots of water. A weak acid like acetic acid can be used to clean up spills of strong base on benches or floors. Excess acid can neutralize the base and the remaining acid solution is safe to sponge away.

Marking criteria	*Marks*
• *Describes two factors that must be considered when using neutralization reactions*	*4*
• *Describes one factor that must be considered when using neutralization reactions and* • *Identifies one factor that must be considered when using neutralization reactions*	*3*
• *Identifies two factors that must be considered when using neutralization reactions OR* • *Describes one factor that must be considered when using neutralization reactions*	*2*
• *Identifies one factor that must be considered when using neutralization reactions*	*1*

Outcomes:H4,H7,H8

Question 19 (2 marks)

Draw citric acid and give its systematic name.

2-hydroxy propane-1,2,3-tricarboxylic acid
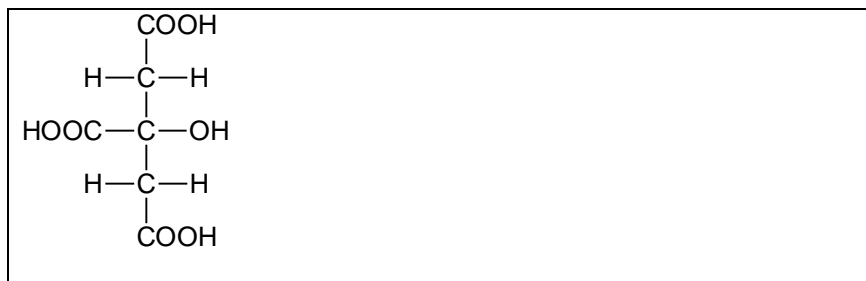
Outcomes:H9

Question 20 (4 marks)

A gas is produced when 10.6 g of sodium carbonate is placed in 50.0 mL of 1.00 molL^{-1} hydrochloric acid. Calculate the volume of gas produced at 25^{0}C and 100 kPa. Include a balanced equation in your answer.

Sample Answer
Na_2CO_3 + 2HCl → 2NaCl + CO_2 + H_2O   *1 mark*
Mol HCl   = M x V   = 1.00 x 0.05 = 0.05 mol
Mol Na_2CO_3 = mass/molar mass   = 10.6/[2(22.99) + 12.01 + 3(16)]   = 0.10 mol   1 mark
Limiting reagent is HCl   0.05 mol
Therefore mol Na_2CO_3=   ½ x 0.05   = 0.025mol
Therefore mol CO_2 =   0.025mol   1 mark
Volume CO_2 =   mol x 24.79   =   0.025 x 24.79 =   0.620L   1 mark
Outcomes:H10

Question 21 (4 marks)

Combustion reactions are important in industry and for society. Scientists must monitor and manage combustion reactions.

(a)   Write an equation for the incomplete combustion of octane, C_8H_{18}.   **1**

Outcomes: H9, H13

Criteria	Marks
Correctly balanced equation for incomplete combustion involving ‣ C, CO, CO_2 , H_2O ‣ C, CO, and H_2O only ‣ C and H_2O only ‣ CO and H_2O only	1

Sample answer:

$$2\ C_8H_{18}(l)\ +\ 17\ O_2(g) \rightarrow 16\ CO(g)\ +\ 18\ H_2O\ (l)$$
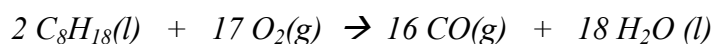
(b)　　Justify the need for the monitoring and management of combustion reactions.　　　　**3**

Outcomes: H4, H9

Criteria	Marks
▸ Explains the problems associated with incomplete combustion in terms of production of pollutants and inefficient use of fuel, producing less energy, and the need for excess oxygen.	3
▸ Explains the problems associated with incomplete combustion in terms of either production of pollutants or inefficient use of fuel, producing less energy or lack of sufficient oxygen	2
▸ States the problems associated with incomplete combustion in terms of production of pollutants and inefficient use of fuel, producing less energy	1

Sample answer:
Monitoring and management of combustion reactions is justified on the basis of pollution control and energy efficiency to ensure that complete rather than incomplete combustion occurs.

The management of combustion reactions involves ensuring that excess oxygen is available so that carbon dioxide, rather than carbon monoxide or carbon is formed and that the maximum amount of energy is released from a given amount of fuel.

Incomplete combustion produces carbon monoxide (toxic) and carbon (sooty pollutant and respiratory hazard). Less energy is released per mole or gram of the fuel, so the efficiency of the combustion process is reduced.

Marks

Question 22 (7 marks)

The graphs below show the fraction of ammonia present at equilibrium when nitrogen and hydrogen react under varying conditions of temperature and pressure.
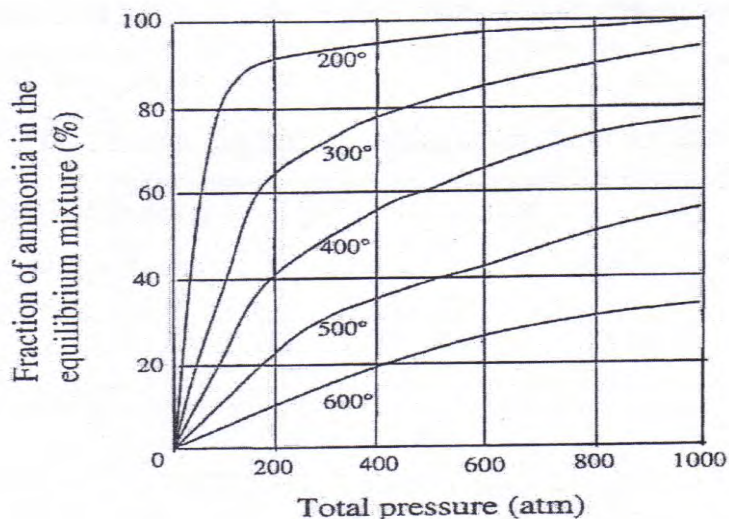
(a) Use the information from the graphs to identify the conditions of temperature and pressure which would give the highest yield of ammonia. **1**

Outcomes: H8, H14

Criteria	Marks
‣ Correct answer using specific pressure and temperature	1

Sample answer:
The highest yield would be produced at 1000 atm and 200ºC

(b) Explain why the Haber process is carried out industrially under compromise conditions of both temperature and pressure. **4**

Outcomes: H3, H4

Criteria	Marks
‣ Explains why the Haber process is a compromise between rate and yield of production by explaining the impact of changing temperature on the rate and yield. AND explains the impact of changing pressure on the rate and yield States the compromise temp 400 ºC and pressure 250 atm	4
Explains why the Haber process is a compromise between rate and yield of production by explaining the impact of changing temperature on the rate and yield. AND explains the impact of changing pressure on the rate or yield but leaves out specific compromise temp and pressure OR explains why the Haber process is a compromise between rate and yield of production by explaining the impact of changing temperature on the rate or yield. AND explains the impact of changing pressure on the rate and yield And /or states the compromise temp 400 ºC and pressure 250 atm	3
Describes the Haber process as a compromise between rate and yield of production by describing the impact of changing temperature on the rate or yield OR describes the impact of changing pressure on the rate or yield.and states specific compromise temp and pressure	2
Describes the Haber process is a compromise between rate and yield of production by changing temperature on the rate or yield. OR describes the impact of changing pressure on the rate or yield OR states compromise temp and pressure of 400 -500 ºC and 250 atm	1

Sample answer:

The maximum yield of ammonia would be achieved at the highest pressure and at the lowest temperature, as these conditions drive the equilibrium towards the right.

$$N_2(g) \ + \ 3H_2(g) \ \rightleftharpoons \ 2NH_3(g) \qquad \Delta H = - \ 92 \ kJmol^{-1}$$

The maximum rate is achieved at the highest pressure (meaning high gas particles concentration) ensuring a more frequent collision and at the highest temperature since gas particles will then have the necessary activation energy to ensure effective collisions.

High pressure favours both high yield and high rate of production as high pressure shifts equilibrium to the right which lowers the pressure due to the gas ratio of 4 moles : 2 moles of gas molecules in the ratio of reactants : products, but the risks and the higher costs of maintaining high pressure lead manufacturers to use a compromise lower pressure of 250 atm.

High temperature favours high rate but low temperature favours high yield as the exothermic forward reaction favours the reverse endothermic process which reduces the yield and hence, a compromise temperature of 400^oC is used.

Marks

(c)   Magnetite is used as the catalyst for this process. Explain the impact of the catalyst on the rate and/or yield of this industrial process.   **2**

Outcomes: H3, H8

Criteria	Marks
▸ Identifies that the catalyst affects the rate (but not the yield) of reaction and provides an explanation	2
▸ Identifies that the catalyst affects the rate (but not the yield) of reaction	1

Sample answer:

The catalyst increases the rate of reaction by providing an alternative lower activation energy pathway for the reaction. At equilibrium, the catalyst will increase the rate of both the backward and forward reactions equally. A catalyst hasten the attainment of equilibrium but does not change the yield of the reaction.

Question 23 (4 marks)

Draw and label a scientific diagram of the apparatus used in the process of esterification   **4**
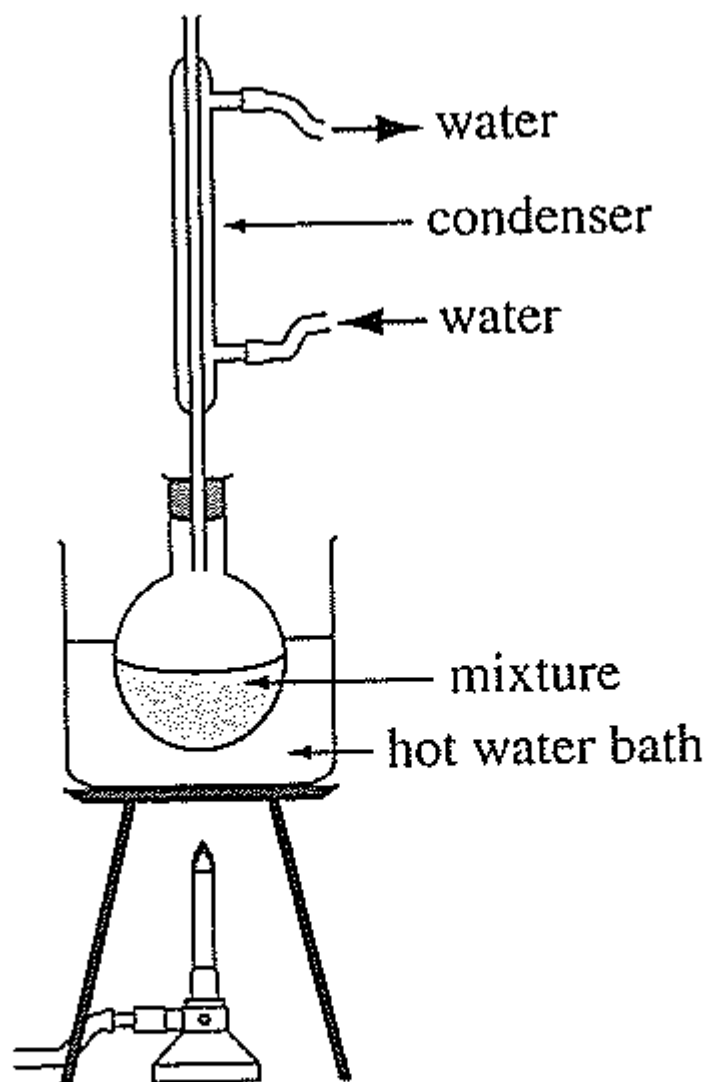
Ans: Diagram showing reflux condensor, flask, bunsen burner, correct water in & out of outer part of condenser.

Marking criteria:	Marks
Neat, correctly labelled diagram showing 4 main parts	4
1 missing	3
2 missing	2
3 missing	1