
Student Number

NORTH SYDNEY GIRLS HIGH SCHOOL

2019

Higher School Certificate
Trial Examination

Chemistry

Total Marks – 100

General Instructions

- Reading Time – 5 minutes
- Working Time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- Write your student number at the top of this booklet and on the multiple choice answer sheet.

Section I

20 Marks

- Attempt Questions 1- 20
- Allow about 35 minutes for this part

Section II

80 Marks

- Attempt question 21 – 39
- Allow about 2 hours and 25 minutes for this part

Section I

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Use the multiple-choice answer sheet provided for Questions 1-20

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 ○

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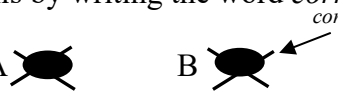


1. Which of the following is an example of a condensation polymer?
    A. Nylon
    B. Polyethylene
    C. Polyvinylchloride
    D. Polytetrafluoroethylene

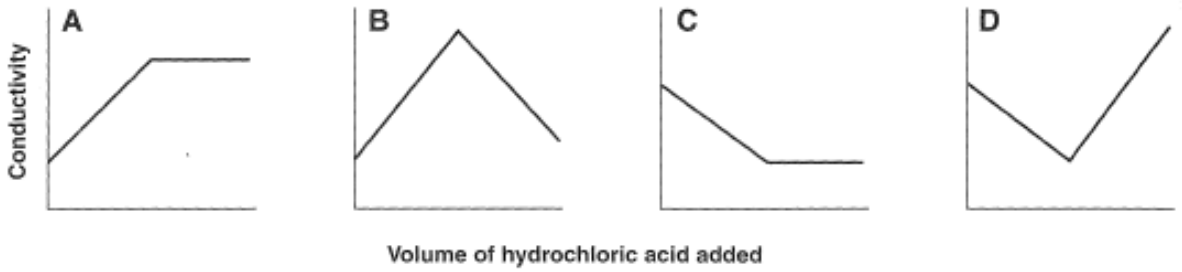
2. Which of the following lists contains members of the same homologous series?
    A. C_2H_6 , C_3H_8 , C_5H_{12}
    B. C_3H_4 , C_3H_6 , C_3H_8
    C. C_3H_7OH , C_2H_5CHO , CH_3COCH_3
    D. C_3H_7OH , C_2H_5CHO , C_2H_5COOH

3. Which of these molecules could be used to produce polystyrene?
    A. CH_2CH_2
    B. CF_2CF_2
    C. CH_2CHCl
    D. $C_6H_5CHCH_2$

4. Which of the following solutions will **NOT** form a precipitate when lead (II) nitrate is added?
    A. NaCl
    B. $NaCH_3COO$
    C. NaOH
    D. Na_2SO_4

5. Which of the following organic substances is the most basic?
    A. Propene
    B. Propan-1-ol
    C. Propanamide
    D. Propan-1-amine

6. A solution of hydrochloric acid is added to a solution of potassium hydroxide and the electrical conductivity of the mixture is measured as the acid is added. Which of the following graphs correctly shows how the conductivity changes as the hydrochloric acid is added?



7. Which of the following systems would **NOT** be in a state of dynamic equilibrium?
   A. A closed 200 mL flask containing 100mL of water
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   C. A Bunsen burner operating with a constant flame temperature
   D. A saturated solution of silver chloride

8. What must a pipette be rinsed with just before it is used to transfer a liquid in preparation for the titration process?
   A. a non-alkaline detergent, then de-ionised water
   B. de-ionised water only
   C. a standard solution, then de-ionised water
   D. small amount of the solution to be used in it

9. Which of the following would **NOT** be produced when methane reacts with chlorine in the presence of ultraviolet light?
   A. hydrogen chloride
   B. tetrachloromethane
   C. chloromethane
   D. hydrogen gas

10. The following equilibrium is set up in a closed container at 350°C:

$$C_{(s)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + H_{2(g)}$$

More $C_{(s)}$ was added to this equilibrium mixture at 350°C. Which of the following will occur?

A. no change in the number of moles of $CO_{(g)}$

B. an increase in the number of moles of $H_{2(g)}$

C. an increase in the number of moles of $H_2O_{(g)}$

D. a decrease in the rate of the forward reaction

11. Consider the following compounds.

I – $CH_3CH_2CH_2COOH$
II – $CH_3CH_2COCH_3$
III – $CH_3CH_2CH_2CHO$

Which of the following statements is correct?

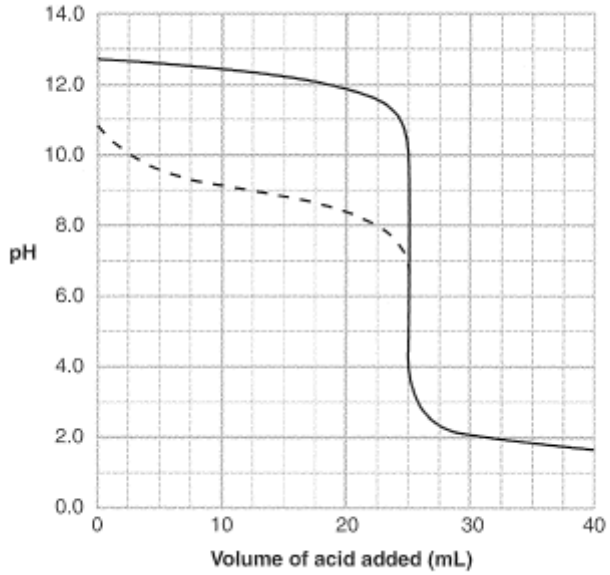
A. Compound I has the lowest boiling point

B. Compound II and III are isomers

C. Compound I and III would combine to form an ester and water in the presence of concentrated sulphuric acid

D. Compound III is an alcohol

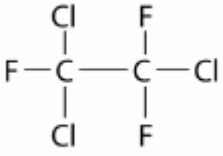
12. Consider the following titration curves.



The solid and dashed lines overlap each other beyond 25mL.
Which of the following describes the correct solutions used in the titrations represented by these lines?

	Solid Line	Dashed Line
A.	strong acid + strong base	strong acid + weak base
B.	strong acid + strong base	weak acid + strong base
C.	weak acid + strong base	weak acid + weak base
D.	strong acid + weak base	weak acid + strong base

13. What is the correct systematic (IUPAC) name of the compound shown below?



A. 1,1,2- trichloro-1,1,2- trifluoroethane
B. 1-chloro-2-dichloro-1-difluoro-2-fluoroethane
C. 1,1,2- trichloro-1,2,2-trifluoroethane
D. Trichlorotrifluoroethane

14. It is important for the pH of blood to be constant and within strict limits. One of the equilibria in the blood is:

$$CO_{2(g)} + H_2O_{(l)} \rightleftharpoons HCO_3^-{}_{(aq)} + H^+_{(aq)}$$

What would happen if the hydrogen ion concentration was increased?

A. more carbon dioxide would be produced in the blood

B. more hydroxide ions would be produced in the blood

C. more carbonate ions would be produced in the blood

D. more hydrogen carbonate ions would be produced in the blood

15. The following reactions are in equilibrium in closed vessels. The pressure in the reaction vessels are changed. In which vessel will this change in the pressure cause **no change** to the ratio of the substances present? Temperature is kept constant.

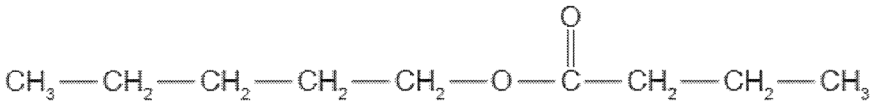
A. $H_2O_{(l)} \rightleftharpoons H_2O_{(g)}$

B. $CO_{(g)} + NO_{2(g)} \rightleftharpoons CO_{2(g)} + NO_{(g)}$

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

D. $3C_2H_{2(g)} \rightleftharpoons C_6H_{6(g)}$

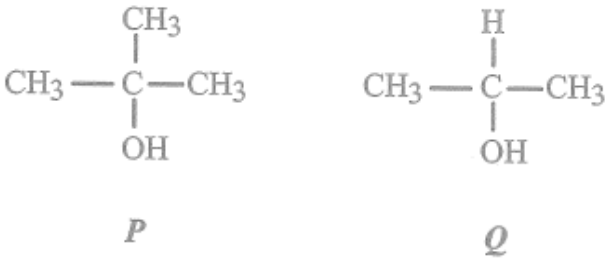
16. The compound with the structural formula shown below is found in bananas and can be produced in a laboratory.



Which of the following is true for this compound?

	Name of compound	**Organic reactants used to produce this compound**
A.	pentyl butanoate	pentanol and butanoic acid
B.	butyl pentanoate	butanol and pentanoic acid
C.	pentyl butanoate	butanol and pentanoic acid
D.	butyl pentanoate	pentanol and butanoic acid

17. How can the following two alcohols be distinguished?



P *Q*

A. Add bromine to each, **P** would decolourise the bromine, while **Q** would not.
B. Add bromine to each, **Q** would decolourise the bromine, while **P** would not.
C. Add acidified potassium permanganate to each, **P** would react with the permanganate (decolourise), while **Q** would not.
D. Add acidified potassium permanganate to each, **Q** would react with the permanganate (decolourise), while **P** would not.

18. Which of the following is the correct option about the process of photosynthesis?

	Enthalpy Change	**Entropy Change**
A.	Positive	Increase
B.	Negative	Decrease
C.	Positive	Decrease
D.	Negative	Increase

19. Which of the following pairs of solutions, when combined, would release the greatest energy?

A. 100 mL of 0.050 $molL^{-1}$ HNO_3 and 200 mL of 0.4 $molL^{-1}$ NaOH
B. 50 mL of 0.20 $molL^{-1}$ HNO_3 and 250 mL of 0.4 $molL^{-1}$ NaOH
C. 100 mL of 0.10 $molL^{-1}$ H_2SO_4 and 200 mL of 0.4 $molL^{-1}$ NaOH
D. 100 mL of 0.50 $molL^{-1}$ CH_3COOH and 200 mL of 0.2 $molL^{-1}$ NaOH

20. Use the data sheet supplied to determine molar solubility (in $molL^{-1}$) of magnesium hydroxide at 25°C.

A. 5.61×10^{-12}
B. 1.12×10^{-4}
C. 1.78×10^{-4}
D. 2.78×10^{-4}

End of Section I

Section II 80 Marks

Marks

Attempt Questions 21- 39.

Allow about 2 hours and 25 minutes for this section.

Answer the questions in the space provided.

Question 21 (4 marks)

The gas acetylene (ethyne, C_2H_2) is used by welders as it burns with a very hot flame.

a) Write the formula equation for the complete combustion of acetylene. **1**

_____

_____

b) If during a welding process 50.0g of acetylene is used, what mass of carbon dioxide is formed? **2**

_____

_____

_____

_____

c) Given that the heat of combustion of ethyne is 1301 $kJmol^{-1}$, how much heat energy would be released in the above reaction? (assume complete combustion). **1**

_____

_____

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_____

Question 22 (6 marks)

The diagram represents a test-tube containing a saturated solution of sodium chloride, with some crystals of sodium chloride at the bottom of the tube.

a) Draw a labelled diagram to show the bonding that occurs when sodium chloride dissolves in water. Begin with one molecule of water. **2**

b) Explain why most ionic solids are generally more soluble in water as temperature increases. **1**

c) Write an equation to describe the equilibrium reaction in the test tube above. **1**

Question 22 continues of the page

d) A few drops of concentrated hydrochloric acid were added to the solution.

i) What would you observe? **1**

ii) Explain your observation in terms of the principles of equilibrium. **1**

Question 23 (4 marks)

Nitric acid has a molar mass of 63.018 $gmol^{-1}$

a) Calculate the pH of a solution of nitric acid, containing 0.0189 gL^{-1} of nitric acid. **2**

b) Calculate the mass of sodium hydroxide that would need to be added to 1.50L of the nitric acid solution to bring the pH of the mixture back to 7.0. **2**

Question 24 (4 marks)

Boric acid (H_3BO_3) is a weak triprotic acid. Its first dissociation equilibrium constant at 25ºC is :

$K_a = 5.75 \times 10^{-10}$

a) If Boric acid was a strong acid, how would you expect its K_a to change? **1**

_____

b) Write the equation for the first ionisation of aqueous boric acid.

_____ **1**

c) Calculate the hydrogen ion concentration of a 1.00mol L^{-1} boric acid solution.

_____ **2**

_____

_____

_____

_____

Question 25 (4 marks)

For the reversible reaction $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

The equilibrium constant $K_{eq} = 780$ at 25ºC

A mixture of nitrogen, hydrogen and ammonia gases are in a 20.0L vessel at 25ºC contains 4.00 mol of nitrogen gas, 4.00 mol of hydrogen gas and 12.0 mol of ammonia gas.

a) Show that this mixture is not at equilibrium. Show all working. **3**

_____

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_____

b) Identify the direction the reaction will favour in order to achieve equilibrium. **1**

_____

_____

Question 26 (6 marks)

Sodium hydroxide reacts with the weak oxalic acid ($H_2C_2O_4$) according to the equation:

$H_2C_2O_{4(aq)} + 2NaOH_{(aq)} \rightarrow Na_2C_2O_{4(aq)} + 2H_2O_{(l)}$

A student standardises a sodium hydroxide solution using a 0.215 mol L^{-1} standard solution of oxalic acid. A series of titrations was carried out using phenolphthalein. It was determined that 36.3 mL of sodium hydroxide was required to reach the end point with 25.0 mL of the oxalic acid solution.

a) Calculate the concentration of the NaOH solution. **3**

b) Write the equation to show that the oxalate ion will produce a basic solution in water. **1**

c) Explain why phenolphthalein was used as the indicator. Make use of the table below. **1**

Indicator	*Colour change*	*pH range over which colour changes*
methyl orange	red - yellow	3.2 – 4.4
bromothymol blue	yellow - blue	6.0 – 7.6
phenolphthalein	colourless - pink	8.3 – 10.0

d) Describe a titration where an appropriate indicator to use would be methyl orange. **1**

Question 27 (4 marks)

2-methylpropan-2-ol is a liquid with a boiling point of 82ºC.

2-methylpropan-2-ol was added to hydrochloric acid. After a short time, the contents of the test tube became cloudy, due to the formation of 2-chloro-2-methylpropane, which is much less soluble in water that 2-methylpropan-2-ol. One other product was formed.

2-chloro-2-methylpropane has a boiling point of 51ºC.

a) Using structural formulae for the carbon compounds, write a balanced equation for the reaction in the test-tube. **2**

b) In terms of bonding, explain why 2-chloro-2-methylpropane has a lower boiling point than 2-methylpropan-2-ol. **2**

Question 28 (2 marks)

Explain how Aboriginal and Torres Strait Islander Peoples removed toxicity from foods such as cycad fruit. Relate this process to your understanding of solubility equilibria. **2**

Question 29 (3 marks)

0.10 $molL^{-1}$ of a weak acid has a pH of 5.1 at 25ºC.

a) Calculate the hydrogen ion concentration. **1**

b) Determine the K_a for this acid. **2**

Question 30 (3 marks)

A buffer solution is prepared by combining 100 mL of 0.100 $molL^{-1}$ acetic (ethanoic) acid and 100mL of 0.100 $molL^{-1}$ of sodium acetate.

a) Justify using the information above, why this solution is classified as a buffer. **2**

b) Describe what would happen to the pH of this solution when a small amount of sodium hydroxide is added. **1**

Question 31 (3 marks)

In two separate experiments pent-2-ene is reacted with:

- hydrogen gas (in the presence of a nickel catalyst)
- chlorine gas

a) Name the product when pent-2-ene is reacted with hydrogen gas. **1**

b) Write a formula equation for the reaction of pent-2-ene with chlorine gas and name the product. **2**

Question 32 (2 marks)

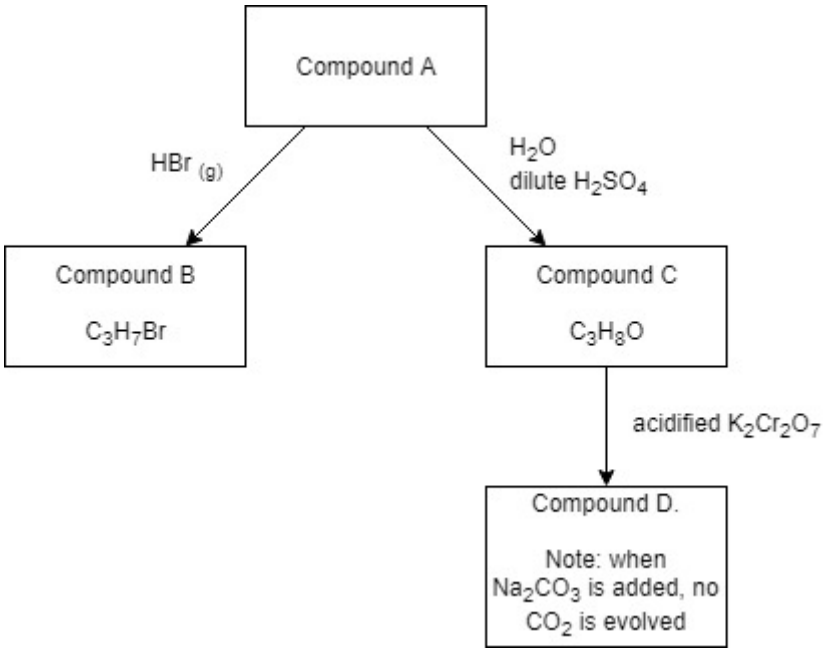
Describe how different observations from flame tests would allow a student to distinguish between solutions containing barium ions and copper ions. **2**

Question 33 (4 marks)

You are given an unknown solution that is suspected to be aqueous calcium iodide. Describe the tests you could perform to confirm the solutions identity. Assuming your suspicions are correct, state the expected observations. **4**

Question 34 (6 marks)

Use the below flowchart to answer the following questions



a) Identify compound A.

_____ **1**

b) Identify one isomer of compound B.

_____ **1**

c) Draw the structural formulae for compounds C and D. **2**

d) Name the type of reaction which occurs when compound B is formed from compound A. **1**

_____

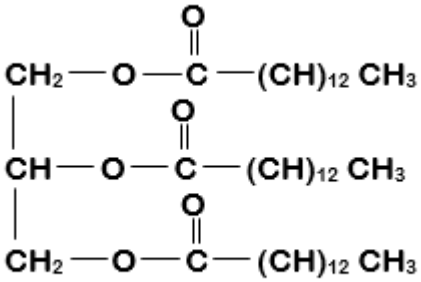
e) Write the equation for the formation of compound C from compound A.

_____ **1**

_____

Question 35 (5 marks)

The compound below is reacted with aqueous sodium hydroxide to produce soap and glycerol.



a) Draw the structure of a soap molecule formed from the above reaction. Use condensed form (as shown). **1**

b) When water is added to the soap, two ions are formed. Write an equation to show this process. **1**

_____

_____

c) With the aid of a diagram explain how soap can be used to remove oil from a piece of clothing. **3**

_____

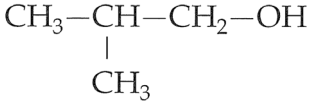
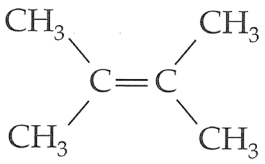
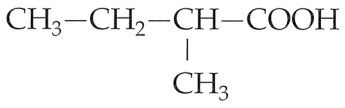
_____

_____

_____

Question 36 (9 marks)

The structural formula for 3 organic compounds are shown below.

Compound 1	Compound 2	Compound 3
		

a) Using IUPAC nomenclature, name the compounds. **3**

Compound 1: _____

Compound 2: _____

Compound 3: _____

b) Predict the order of boiling points (lowest to highest) of these compounds. Justify your order by comparing relative strengths of their intermolecular forces. **4**

_____

_____

_____

_____

_____

_____

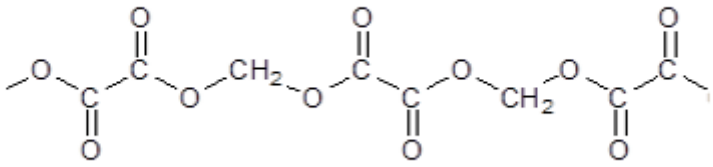
_____

_____

c) Draw the structural formula of two other molecules that are isomers of compound 1. **2**

Question 37 (3 marks)

The structure below represents a fragment of a polymer from two different monomers.



a) Draw one of the monomers that could be used to produce this polymer. **1**

b) With each step in this polymerisation process, what else will be produced? **1**

_____

_____

c) Describe one use of this polymer. **1**

_____

_____

_____

_____

Question 38 (4 marks) **4**

Changes in the definitions of acids have occurred over time. Compare and contrast Arrhennius' theory of acids with that proposed by Bronsted – Lowry and describe how the Bronsted-Lowry theory overcame some of the limitations of Arrhennius' ideas.

Question 39 (4 marks)

The hydrogen arsenate ion ($HAsO_4^{2-}$) is amphiprotic.

a) Define the term "amphiprotic species". **1**

b) Use appropriate equations to demonstrate that the hydrogen arsenate ion is amphiprotic. **2**

c) Identify the conjugate acid of the hydrogen arsenate ion. **1**

END OF PAPER

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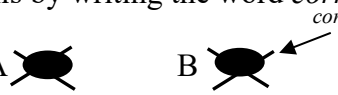

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   B. C_3H_4 , C_3H_6 , C_3H_8

   C. C_3H_7OH , C_2H_5CHO , CH_3COCH_3

   D. C_3H_7OH , C_2H_5CHO , C_2H_5COOH

3. Which of these molecules could be used to produce polystyrene?

   A. CH_2CH_2

   B. CF_2CF_2

   C. CH_2CHCl

   D. $C_6H_5CHCH_2$

4. Which of the following solutions will **NOT** form a precipitate when lead (II) nitrate is added?

   A. NaCl

   B. $NaCH_3COO$

   C. NaOH

   D. Na_2SO_4

5. Which of the following organic substances is the most basic?

   A. Propene

   B. Propan-1-ol

   C. Propanamide

   D. Propan-1-amine

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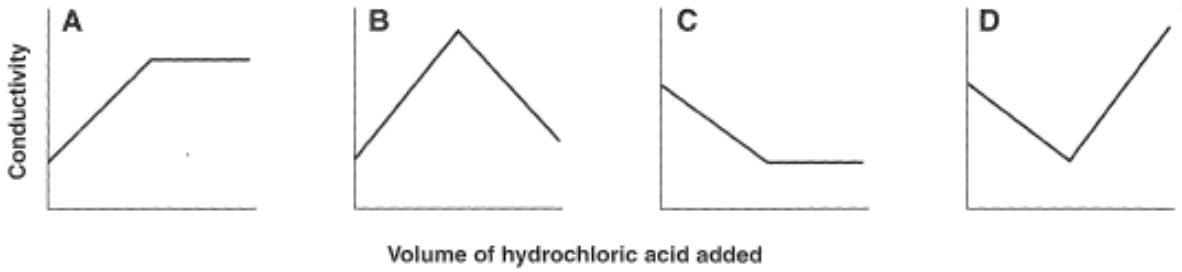

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   A. hydrogen chloride
   B. tetrachloromethane
   C. chloromethane
   D. hydrogen gas

10. The following equilibrium is set up in a closed container at 350°C:

$$C_{(s)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + H_{2(g)}$$

More $C_{(s)}$ was added to this equilibrium mixture at 350°C. Which of the following will occur?

A. no change in the number of moles of $CO_{(g)}$

B. an increase in the number of moles of $H_{2(g)}$

C. an increase in the number of moles of $H_2O_{(g)}$

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Which of the following statements is correct?

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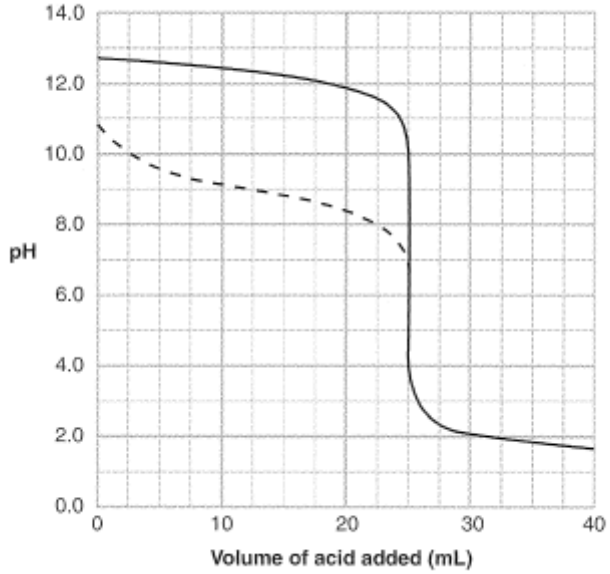

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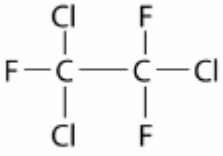
B.	strong acid + strong base	weak acid + strong base
C.	weak acid + strong base	weak acid + weak base
D.	strong acid + weak base	weak acid + strong base

13. What is the correct systematic (IUPAC) name of the compound shown below?



A. 1,1,2- trichloro-1,1,2- trifluoroethane
B. 1-chloro-2-dichloro-1-difluoro-2-fluoroethane
C. 1,1,2- trichloro-1,2,2-trifluoroethane
D. Trichlorotrifluoroethane

14. It is important for the pH of blood to be constant and within strict limits. One of the equilibria in the blood is:

$$CO_{2(g)} + H_2O_{(l)} \rightleftharpoons HCO_3^-{}_{(aq)} + H^+_{(aq)}$$

What would happen if the hydrogen ion concentration was increased?

A. more carbon dioxide would be produced in the blood

B. more hydroxide ions would be produced in the blood

C. more carbonate ions would be produced in the blood

D. more hydrogen carbonate ions would be produced in the blood

15. The following reactions are in equilibrium in closed vessels. The pressure in the reaction vessels are changed. In which vessel will this change in the pressure cause **no change** to the ratio of the substances present? Temperature is kept constant.

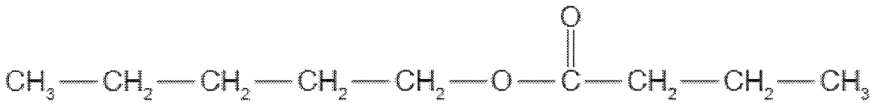
A. $H_2O_{(l)} \rightleftharpoons H_2O_{(g)}$

B. $CO_{(g)} + NO_{2(g)} \rightleftharpoons CO_{2(g)} + NO_{(g)}$

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

D. $3C_2H_{2(g)} \rightleftharpoons C_6H_{6(g)}$

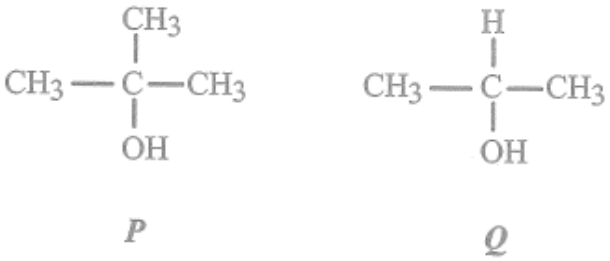
16. The compound with the structural formula shown below is found in bananas and can be produced in a laboratory.



Which of the following is true for this compound?

	Name of compound	**Organic reactants used to produce this compound**
A.	**pentyl butanoate**	**pentanol and butanoic acid**
B.	butyl pentanoate	butanol and pentanoic acid
C.	pentyl butanoate	butanol and pentanoic acid
D.	butyl pentanoate	pentanol and butanoic acid

17. How can the following two alcohols be distinguished?



P *Q*

A. Add bromine to each, **P** would decolourise the bromine, while **Q** would not.

B. Add bromine to each, **Q** would decolourise the bromine, while **P** would not.

C. Add acidified potassium permanganate to each, **P** would react with the permanganate (decolourise), while **Q** would not.

D. Add acidified potassium permanganate to each, Q would react with the permanganate (decolourise), while P would not.

18. Which of the following is the correct option about the process of photosynthesis?

	Enthalpy Change	**Entropy Change**
A.	Positive	Increase
B.	Negative	Decrease
C.	**Positive**	**Decrease**
D.	Negative	Increase

19. Which of the following pairs of solutions, when combined, would release the greatest energy?

A. 100 mL of 0.050 $molL^{-1}$ HNO_3 and 200 mL of 0.4 $molL^{-1}$ NaOH

B. 50 mL of 0.20 $molL^{-1}$ HNO_3 and 250 mL of 0.4 $molL^{-1}$ NaOH

C. 100 mL of 0.10 $molL^{-1}$ H_2SO_4 and 200 mL of 0.4 $molL^{-1}$ NaOH

D. 100 mL of 0.50 $molL^{-1}$ CH_3COOH and 200 mL of 0.2 $molL^{-1}$ NaOH

20. Use the data sheet supplied to determine molar solubility (in $molL^{-1}$) of magnesium hydroxide at 25°C.

A. 5.61×10^{-12}

B. 1.12×10^{-4}

C. 1.78×10^{-4}

D. 2.78×10^{-4}

End of Section I

Section II 80 Marks

Marks

Attempt Questions 21- 39.

Allow about 2 hours and 25 minutes for this section.

Answer the questions in the space provided.

Question 21 (4 marks)

The gas acetylene (ethyne, C_2H_2) is used by welders as it burns with a very hot flame.

a) Write the formula equation for the complete combustion of acetylene. **1**

$C_2H_2 + 5/2O_2 \rightarrow 2CO_2 + H_2O$

b) If during a welding process 50.0g of acetylene is used, what mass of carbon dioxide is formed? **2**

$nC_2H_2 = 50.0/26.036 = 1.92$

$nCO_2 = 3.84$

$mCO_2 = nM = 3.84 \times 44.01 = 169.0g$

c) Given that the heat of combustion of ethyne is 1301 $kJmol^{-1}$, how much heat energy would be released in the above reaction? (assume complete combustion). **1**

Energy released = n x ΔHc

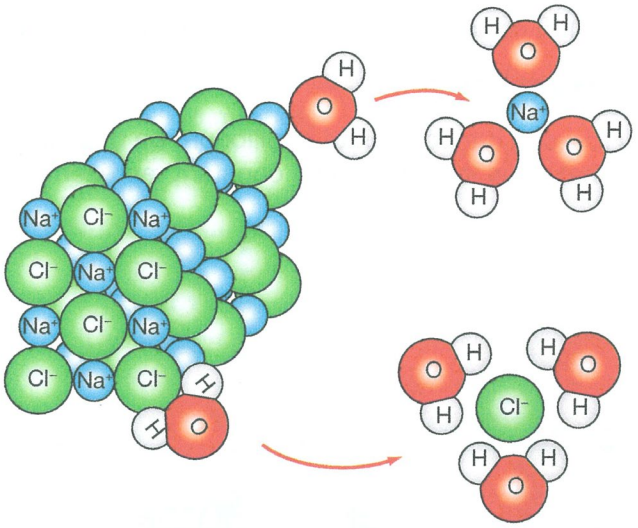
= 1.92 x 1301 = 2498 kJ (2500kJ 3 sig fig)

Question 22 (6 marks)

The diagram represents a test-tube containing a saturated solution of sodium chloride, with some crystals of sodium chloride at the bottom of the tube.

a) Draw a labelled diagram to show the bonding that occurs when sodium chloride dissolves in water. Begin with one molecule of water. **2**

Labelled diagram showing a sodium ion and a chloride ion attracted to a water molecule (correct poles).



1

b) Explain why most ionic solids are generally more soluble in water as temperature increases.

As temperature increases, the ions in the lattice increase their vibrational motion, thus increasing the rate at which they leave the lattice and dissolve in the water.

OR description of how must dissociation reactions are endothermic and that the addition of heat means the forward reaction is favoured and this increases the rate of dissolving.

c) Write an equation to describe the equilibrium reaction in the test tube above.

$NaCl(s) \rightleftharpoons Na^+(aq) + Cl^-(aq)$ **1**

Question 22 continues of the page

d) A few drops of concentrated hydrochloric acid were added to the solution.

i) What would you observe? **1**

A white precipitate would form.

ii) Explain your observation in terms of the principles of equilibrium.

Explanation: the reverse reaction is favoured in order to decrease chloride ion concentration. **1**

Question 23 (4 marks)

Nitric acid has a molar mass of 63.018 $gmol^{-1}$

a) Calculate the pH of a solution of nitric acid, containing 0.0189 gL^{-1} of nitric acid. **2**

Nitric acid is a strong acid. Therefore the acid concentration will equal the hydrogen ion concentration

ie $0.0189/63.018 = 0.0003 molL^{-1}$
$pH = -\log[H^+]$
$pH = -\log(0.0003) = 3.5$

b) Calculate the mass of sodium hydroxide that would need to be added to 1.50L of the nitric acid solution to bring the pH of the mixture back to 7.0.

nNaOH required to neutralise HNO3 = nHNO3 = 0.0003 x 1.5 = 0.00045 **2**

mass of NaOH = nM = 0.00045 x 40 = 0.018g

Question 24 (4 marks)

Boric acid (H_3BO_3) is a weak triprotic acid. Its first dissociation equilibrium constant at 25°C is :

$K_a = 5.75 \times 10^{-10}$

a) If Boric acid was a strong acid, how would you expect its K_a to change? **1**

The K_a would be bigger.

b) Write the equation for the first ionisation of aqueous boric acid.

$H_3BO_3 + H_2O \rightarrow H_2BO_3^- + H_3O^+$

OR $H_3BO_3 \rightarrow H_2BO_3^- + H^+$ **1**

c) Calculate the hydrogen ion concentration of a 1.00mol L^{-1} boric acid solution.

$K_a = [H_2BO_3^-] \times [H^+]/[H_3BO_3]$

$5.75 \times 10^{-10} = [H^+]^2/1$ **2**
$[H^+] = \sqrt{5.75 \times 10^{-10}}$
$[H^+] = 2.39 \times 10^{-5}\ molL^{-1}$

Question 25 (4 marks)

For the reversible reaction $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

The equilibrium constant $K_{eq} = 780$ at 25°C

A mixture of nitrogen, hydrogen and ammonia gases are in a 20.0L vessel at 25°C contains 4.00 mol of nitrogen gas, 4.00 mol of hydrogen gas and 12.0 mol of ammonia gas.

a) Show that this mixture is not at equilibrium. Show all working. **3**

K_{eq} at 25°C = 780

$Q = [NH_3]^2/[N_2] \times [H_2]^3$

$[NH_3] = 12/20 = 0.6$ molL^{-1}

$[N_2] = 4/20 = 0.2$ molL^{-1}

$[H_2] = 4/20 = 0.2$ molL^{-1}

$Q = (0.6)^2/(0.2)(0.2)^3 = 0.36/0.0016 = 225.$

Since Q is not equal to K_{eq}, the system is not in equilibrium.

b) Identify the direction the reaction will favour in order to achieve equilibrium.

Since Q needs to increase to equal K_{eq}, the ammonia concentration must increase. Therefore the forward reaction is favoured. **1**

Question 26 (6 marks)

Sodium hydroxide reacts with the weak oxalic acid ($H_2C_2O_4$) according to the equation:

$H_2C_2O_{4(aq)} + 2NaOH_{(aq)} \rightarrow Na_2C_2O_{4(aq)} + 2H_2O_{(l)}$

A student standardises a sodium hydroxide solution using a 0.215 mol L^{-1} standard solution of oxalic acid. A series of titrations was carried out using phenolphthalein. It was determined that 36.3 mL of sodium hydroxide was required to reach the end point with 25.0 mL of the oxalic acid solution.

a) Calculate the concentration of the NaOH solution. **3**

The concentration of the oxalic acid is 0.215molL^{-1}

The volume of acid used to neutralise the base (end point/equivalence point) is 0.0250L

$nH_2C_2O_4 = CV = 0.215 \times 0.025 = 0.005375.$

nNaOH required for neutralisation = $2 \times 0.005375 = 0.01075.$

The concentration of NaOH = $n/V = 0.01075/0.0363$

$= 0.296$molL^{-1}

1 Mark deducted if answer not in 3 sig. fig.

b) Write the equation to show that the oxalate ion will produce a basic solution in water. **1**

$C_2O_4^{2-} + H_2O \leftrightarrow HC_2O_4^- + OH^-$

1

c) Explain why phenolphthalein was used as the indicator. Make use of the table below.

Indicator	*Colour change*	*pH range over which colour changes*
methyl orange	red - yellow	3.2 – 4.4
bromothymol blue	yellow - blue	6.0 – 7.6
phenolphthalein	colourless - pink	8.3 – 10.0

Phenolphthalein changes colour in the pH range 8.3 to 10.0 ie in the alkali range. The salt formed during the above reaction is an alkali salt so equivalence point/endpoint will occur when the solution is alkali/basic. Another acceptable response is in terms of titration curve of weak acid strong base with produce an equivalence point greater than 7.0.

d) Describe a titration where an appropriate indicator to use would be methyl orange. **1**

A strong acid titrated into a weak base would require methyl orange as an indicator (as the salt formed is acidic – not required for mark).

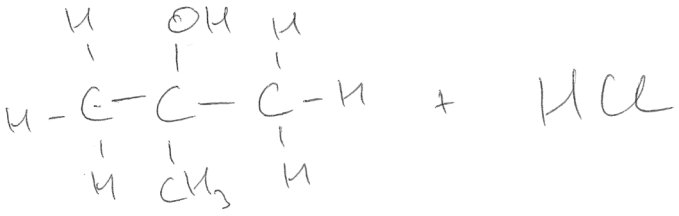
Question 27 (4 marks)

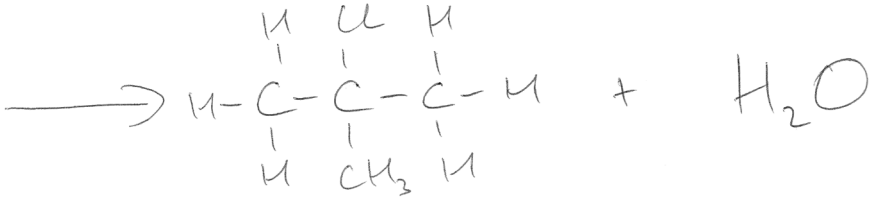
2-methylpropan-2-ol is a liquid with a boiling point of 82°C.

2-methylpropan-2-ol was added to hydrochloric acid. After a short time, the contents of the test tube became cloudy, due to the formation of 2-chloro-2-methylpropane, which is much less soluble in water that 2-methylpropan-2-ol. One other product was formed.

2-chloro-2-methylpropane has a boiling point of 51°C.

a) Using structural formulae for the carbon compounds, write a balanced equation for the reaction in the test-tube. **2**





2

b) In terms of bonding, explain why 2-chloro-2-methylpropane has a lower boiling point than 2-methylpropan-2-ol.

2-methylpropan-2-ol forms hydrogen bonds between its molecules. This is a particularly strong form of intermolecular bonding resulting in a higher boiling point. 2-chloro-2-methylpropane has dipole/dipole interactions between its molecules which are not as strong as hydrogen bonds and therefore has a lower boiling point.

Question 28 (2 marks)

Explain how Aboriginal and Torres Strait Islander Peoples removed toxicity from foods such as cycad fruit. Relate this process to your understanding of solubility equilibria. **2**

Description for how Indigenous people remove toxicity from food and relate process to solubility equilibria for explanation

Question 29 (3 marks)

0.10 $molL^{-1}$ of a weak acid has a pH of 5.1 at 25°C.

a) Calculate the hydrogen ion concentration. **1**

$pH = -\log[H^+]$

$= \log^{-5.1} = 7.94 \times 10^{-6}$

b) Determine the K_a for this acid.

$Ka = [H^+] \times [A^-]/[HA] = (7.94 \times 10^{-6}) \times (7.94 \times 10^{-6})/0.10$

$= 6.30 \times 10^{-10}$

2

Question 30 (3 marks)

A buffer solution is prepared by combining 100 mL of 0.100 $molL^{-1}$ acetic (ethanoic) acid and 100mL of 0.100 $molL^{-1}$ of sodium acetate.

a) Justify using the information above, why this solution is classified as a buffer. **2**

This solution will act as a buffer as it contains equal concentrations of a weak acid and its conjugate base (salt of the weak acid)

b) Describe what would happen to the pH of this solution when a small amount of sodium hydroxide is added.

The pH of the solution would barely change. **(1 mark) NB; mark deducted if explanation given included wrong chemistry.**

1

Question 31 (3 marks)

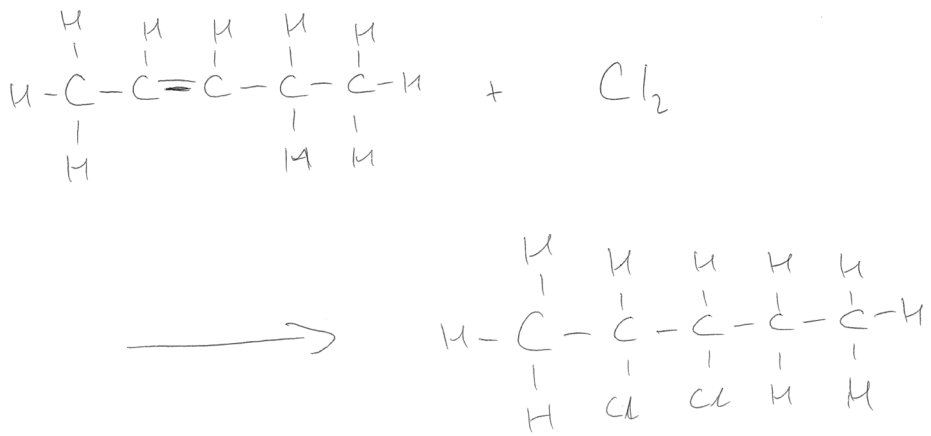
In two separate experiments pent-2-ene is reacted with:

- hydrogen gas (in the presence of a nickel catalyst)
- chlorine gas

a) Name the product when pent-2-ene is reacted with hydrogen gas. **1**

Pentane

b) Write a formula equation for the reaction of pent-2-ene with chlorine gas and name the product. **2**



Correct equation for reaction (structural, condensed structural or molecular)
2,3-dichloropentane

Question 32 (2 marks)

Describe how different observations from flame tests would allow a student to distinguish between solutions containing barium ions and copper ions. **2**

The flame would turn a yellow/green colour when a solution containing barium ions was sprayed into it.

The flame would turn a blue/green colour when a solution containing copper ions was sprayed into it.

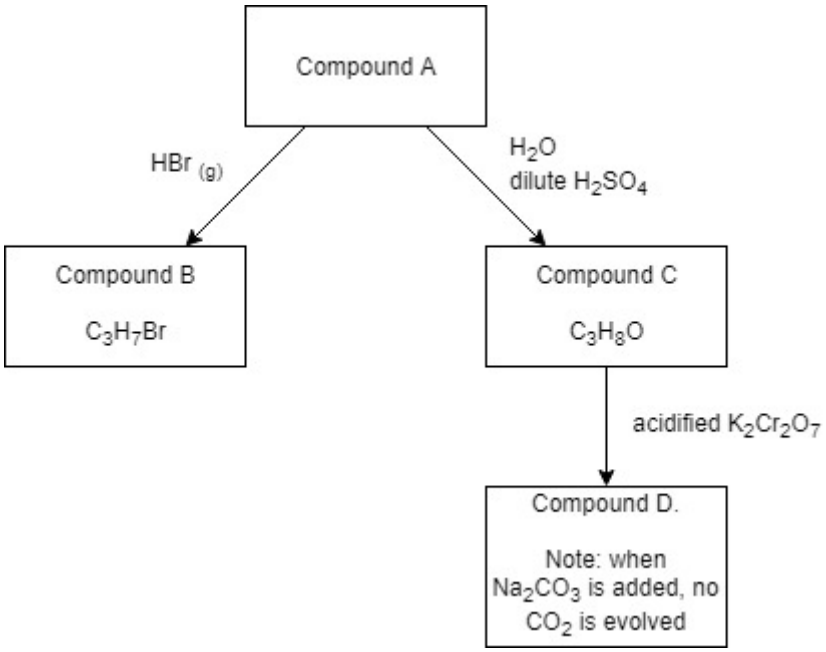
Question 33 (4 marks)

You are given an unknown solution that is suspected to be aqueous calcium iodide. Describe the tests you could perform to confirm the solutions identity. Assuming your suspicions are correct, state the expected observations. **4**

Calcium ions would give a red colour **(1 mark)** when flame tested **(1 mark).**
Iodide ions would react with lead ions **(1 mark)** giving a bright yellow precipitate **(1 mark).**

Question 34 (6 marks)

Use the below flowchart to answer the following questions



a) Identify compound A.

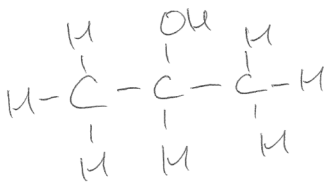
Propene **1**

b) Identify one isomer of compound B.

1-bromopropane or 2-bromopropane **1**

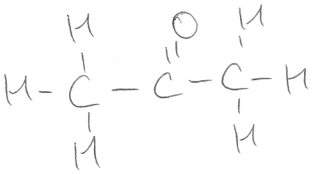
c) Draw the structural formulae for compounds C and D. **2**

Compound C



1

Compound D



1

d) Name the type of reaction which occurs when compound B is formed from compound A.

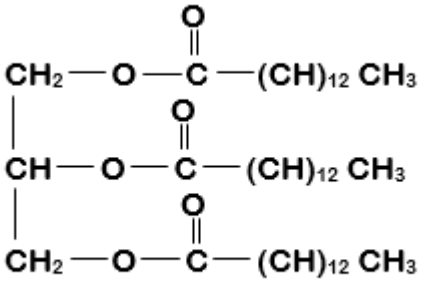
Addition

e) Write the equation for the formation of compound C from compound A.

$C_3H_6 + H_2O$ (with dilute H_2SO_4) $\rightarrow C_3H_8O$

Question 35 (5 marks)

The compound below is reacted with aqueous sodium hydroxide to produce soap and glycerol.



a) Draw the structure of a soap molecule formed from the above reaction. Use condensed form (as shown). **1**

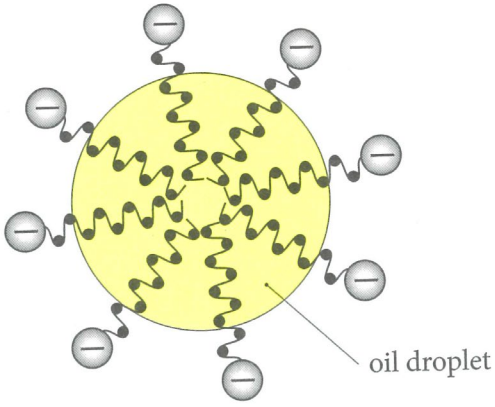
$CH_3(CH_2)_{12}COONa$

b) When water is added to the soap, two ions are formed. Write an equation to show this process. 1

$CH_3(CH_2)_{12}COONa(s) \rightarrow Na^+ + CH_3(CH_2)_{12}COO^-$

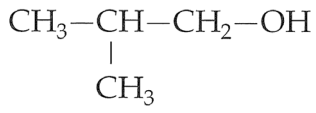
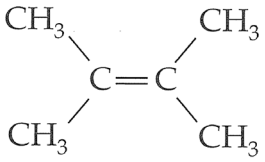
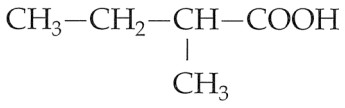
c) With the aid of a diagram explain how soap can be used to remove oil from a piece of clothing. **3**

The soap ion has a polar and a non-polar part. The non-polar part attaches itself to the oil with dispersion forces, as the oil is also non-polar. The charged part ion is attracted to the water molecules as they are polar (see diagram). With agitation, the oil is removed from the clothing.



Question 36 (9 marks)

The structural formula for 3 organic compounds are shown below.

Compound 1	Compound 2	Compound 3
		

a) Using IUPAC nomenclature, name the compounds. **3**

Compound 1: 2-methylpropan-1-ol

Compound 2: 2,3-dimethylbut-2-ene

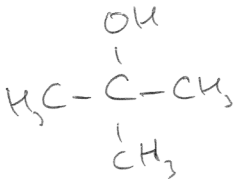
Compound 3: 2-methylbutanoic acid

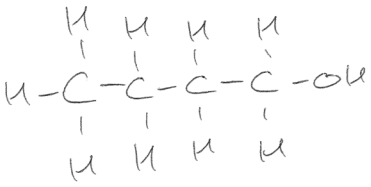
b) Predict the order of boiling points (lowest to highest) of these compounds. Justify your order by comparing relative strengths of their intermolecular forces. **4**

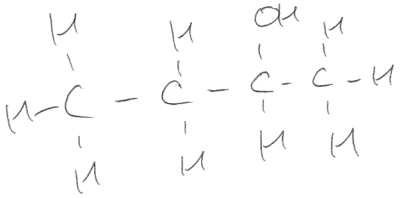
The order from lowest to highest boiling points is:

Compound 2 then compound 1 then compound
Compound 2 only has dispersion forces which are relatively weak.
Compound 1 has dispersion forces as well as hydrogen bonding which is a stronger intermolecular force than dispersion forces, therefore has a higher boiling point than compound 2.
Compound 3 has dispersion forces and more/stronger hydrogen bonds than compound 1 and therefore has the highest boiling point.

c) Draw the structural formula of two other molecules that are isomers of compound 1. **2**

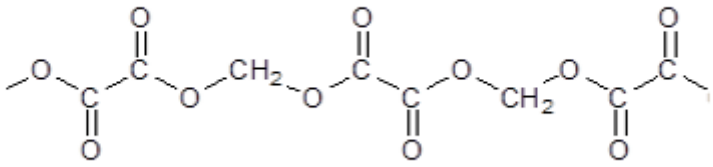




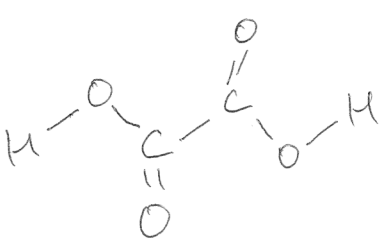


Question 37 (3 marks)

The structure below represents a fragment of a polymer from two different monomers.



a) Draw one of the monomers that could be used to produce this polymer. **1**



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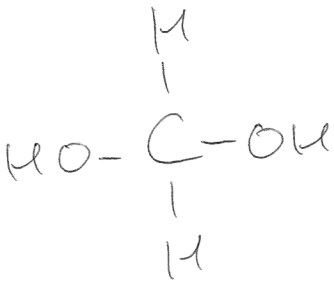

1

1

b) With each step in this polymerisation process, what else will be produced?

Water

c) Describe one use of this polymer.

This polymer is a polyester so could be used to make clothes or produce a strong string

Question 38 (4 marks)

Changes in the definitions of acids have occurred over time. Compare and contrast Arrhennius' theory of acids with that proposed by Bronsted – Lowry and describe how the Bronsted-Lowry theory overcame some of the limitations of Arrhennius' ideas. **4**

2 marks- correct identification/description of Arrhenius and BL theories noting similarity between them.
2 marks- correct identification of limitation of Arrhenius and how it was overcome by BL.

The Arrhenius theory of acids states that acids were substances that ionised in water producing hydrogen ions.
It did not attempt to explain the role of the water and only considered acids as substances that ionised in water and not under any other conditions.
The Bronsted/Lowry theory states that an acid was a substance that donated a proton (hydrogen ion) to another species called the base.
An acid such as hydrogen chloride in water donates a proton to the water molecules. Since the water molecules accept the protons, the water is defined as Bronsted/Lowry base and the role of the water in the ionisation process has been explained.

The Bronsted/Lowry theory also allowed for acid/base reactions outside of aqueous solutions.

Question 39 (4 marks)

The hydrogen arsenate ion ($HAsO_4^{2-}$) is amphiprotic.

a) Define the term "amphiprotic species". **1**

An amphiprotic species is an ion or molecule that can accept or donate a hydrogen ion during a chemical reaction.

b) Use appropriate equations to demonstrate that the hydrogen arsenate ion is amphiprotic. **2**

$HAsO_4^{2-} + H_3O^+ \rightarrow H_2AsO4^- + H_2O$ (acting as a base)

$HAsO_4^{2-} + OH^- \rightarrow AsO_4^{3-} + H_2O$ (acting as an acid)

c) Identify the conjugate acid of the hydrogen arsenate ion.

$H_2AsO_4^-$ or the dihydrogen arsenate ion. **1**

END OF PAPER