Student Number ☐☐☐☐☐☐☐☐☐

ST GEORGE
GIRLS HIGH
SCHOOL

2019

HIGHER
SCHOOL
CERTIFICATE
EXAMINATION

This is a TRIAL PAPER ONLY and does not necessarily reflect the content or format of the final Higher School Certificate Examination for this subject.

Chemistry

General Instructions	• Reading time – 5 minutes
	• Working time – 3 hours
	• Write using black pen
	• Draw diagrams using a 2B pencil
	• NESA approved calculators may be used
	• A formulae sheet, data sheet and Periodic Table are provided at the back of this paper
	• For questions in Section II, show all relevant working in questions involving calculations
	• Write your Student Number at the top of pages 1, 2, 3, 11, 17, 21, 27, 29 and on any extra pages used and on each separate page in Section II answer booklet.
	• Multiple Choice Answer Sheet is on the back of the front page. Write your Student Number at the top. You may remove this sheet.

Total marks: 100

Section I – 20 marks (pages 2 – 10)
• Attempt Questions 1-20
• Allow about 35 minutes for this section

Section II – 80 marks (pages 11 – 30)
• Attempt Questions 21-36
• Allow about 2 hours and 25 minutes for this section

SECTION	**MARK**
Section I	/20
Section II	/80
Total	/100

– 1 –

Trial HSC Chemistry 2019

Multiple Choice Answer Sheet

Part A
Total marks (20)
Attempt Questions (1-20)

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

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 this by writing the word *correct* and drawing an arrow as follows:

correct

A ⊗   B ⊗   C ◯   D ◯

1.	A ◯	B ◯	C ◯	D ◯
2.	A ◯	B ◯	C ◯	D ◯
3.	A ◯	B ◯	C ◯	D ◯
4.	A ◯	B ◯	C ◯	D ◯
5.	A ◯	B ◯	C ◯	D ◯
6.	A ◯	B ◯	C ◯	D ◯
7.	A ◯	B ◯	C ◯	D ◯
8.	A ◯	B ◯	C ◯	D ◯
9.	A ◯	B ◯	C ◯	D ◯
10.	A ◯	B ◯	C ◯	D ◯
11.	A ◯	B ◯	C ◯	D ◯
12.	A ◯	B ◯	C ◯	D ◯
13.	A ◯	B ◯	C ◯	D ◯
14.	A ◯	B ◯	C ◯	D ◯
15.	A ◯	B ◯	C ◯	D ◯
16.	A ◯	B ◯	C ◯	D ◯
17.	A ◯	B ◯	C ◯	D ◯
18.	A ◯	B ◯	C ◯	D ◯
19.	A ◯	B ◯	C ◯	D ◯
20.	A ◯	B ◯	C ◯	D ◯

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Part A – 20 marks
Attempt Questions (1-20)
Allow about 35 minutes for this part

Use the multiple-choice answer sheet for Questions 1 – 20.

_____

1. Which of the following demonstrates a conjugate acid/base pair?

    A. HCl/Cl^-

    B. HNO_3/H^+

    C. H_2SO_4/SO_4^{2-}

    D. HCO_3^-/H^+

2. Saturated organic compounds:

    A. contain only single bonds between carbon atoms.

    B. contain at least one double or triple bond between carbon atoms.

    C. contain only carbon and hydrogen atoms.

    D. contain at least one double or triple bond between carbon and oxygen atoms.

3. Identify the correct name for the following compound.
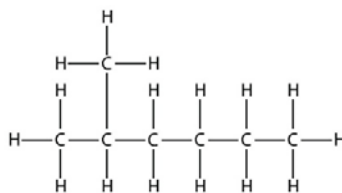
    A. 1,1-dimethylpentane

    B. 2-methylhexane

    C. heptane

    D. isohexane

– 3 –

4. In your studies you performed a first-hand investigation to determine the concentration of copper ions in solution. Identify the process you used to do this.

    A. Gravimetric analysis

    B. Colourimetry

    C. Atomic Absorption Spectroscopy

    D. Precipitation titrations

5. The diagram below shows the pH of a variety of everyday substances.
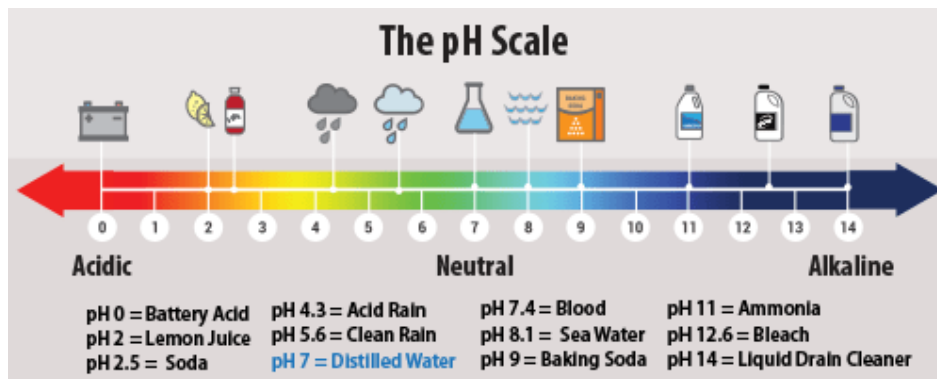
Which of the following statement is correct?

    A. Lemon juice is 2 times less acidic than battery acid.

    B. Baking soda is 100 times more basic than ammonia.

    C. Liquid drain cleaner is 1000 times more basic than ammonia.

    D. All sources of water are either acidic or neutral.

6. Which of the following contains only inorganic acids and bases?

    A. Sulfuric acid, citric acid, ammonia

    B. Citric acid, ethanoic acid, ammonia

    C. Hydrochloric acid, ethanoic acid, sodium hydroxide

    D. Sulfuric acid, nitric acid, sodium hydroxide

7. Which of the following contains only basic salts?

    A. Sodium acetate, sodium chloride, sodium phosphate

    B. Sodium acetate, sodium carbonate, sodium phosphate

    C. Potassium nitrate, potassium acetate, potassium chloride

    D. Potassium acetate, potassium carbonate, potassium nitrate

8. Which of the following substances is amphiprotic?

   A. Sodium acetate

   B. Aluminium oxide

   C. Sodium hydrogen carbonate

   D. Potassium phosphate

9. An organic compound is prepared from ethanol by a four step process. Each of the four steps gives a yield of 70%. What will be the yield of the organic compound based on the initial amount of ethanol?

   A. 24%

   B. 30%

   C. 34%

   D. 70%

10. According to the Collision Model of reaction rate, the rate of a reaction:

   A. increases when temperature increases, due to a larger proportion of molecules having enough energy to react.

   B. is unaffected by temperature change, because activation energy does not change with temperature.

   C. decreases when temperature increases, in part because entropy for reactions decreases.

   D. may increase or decrease as temperature changes, depending on whether entropy is positive or negative.

11. The equation below demonstrates one limitation of whose acid-base theory?

$$HCl_{(g)} + NH_{3(g)} \rightarrow NH_4Cl_{(s)}$$
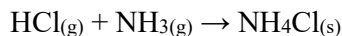
   A. Brønsted-Lowry

   B. Arrhenius

   C. Lewis

   D. Gay-Lussac

– 5 –

12. Calcium oxide reacts with carbon according to the following equation:

$$CaO_{(s)} + C_{(s)} \rightarrow Ca_{(s)} + CO_{(g)}$$
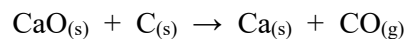
Use the following data to determine the temperature at which this reaction will occur.

$$\Delta H = 525 \text{ kJ mol}^{-1}$$
$$\Delta S = 193.6 \text{ J K}^{-1} \text{ mol}^{-1}$$

A. 2.7 K

B. 2.7 °C

C. 2712 K

D. 2712 °C

13. Identify which organic substance the following represents.
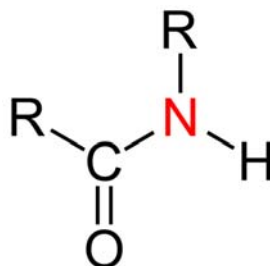
A. Ketone

B. Amide

C. Amine

D. Aldehyde

14. Choose the row which correctly names and identifies the type of alcohol shown below.
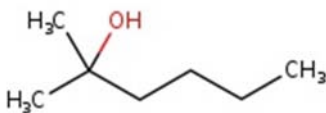
	Name of alcohol	Type of alcohol
A.	2-methylhexan-2-ol	Tertiary
B.	2,2-dimethylpentan-1-ol	Tertiary
C.	2-methylhexan-2-ol	Secondary
D.	2,2-dimethylhexanol	Secondary

15. The following diagram is a mixed up series of steps of how surfactants work. What is their correct order?

    A. 2, 1, 3, 4

    B. 2, 3, 4, 1

    C. 2, 3, 4, 1

    D. 2, 1, 4, 3

Key: Surfactant ions

1.

2.

3.

4.
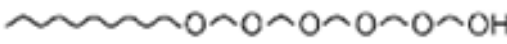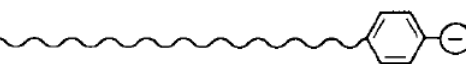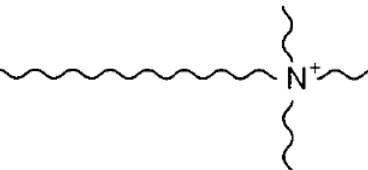
16. Limestone (calcium carbonate) contributes to the hardness of water by releasing calcium ions in water. Hard water is water that contains calcium and magnesium ions. The table below compares soaps to detergents.

Table 1: Comparison of Soap and Detergent

Soaps	Detergents
Are sodium salts of long chain carboxylic acids	Are sodium salts of long chain benzene sulphonic acids or alkyl sulfate
Obtain by natural resources from plants and animals (fats, oils)	Synthetic materials, hydrocarbon of petroleum or coal
Calcium and magnesium salts are insoluble in water	Calcium and magnesium salts are soluble in water
Produces scum in hard water which affects it's cleaning action	Hard water does not affect it's cleaning action
Biodegradable	Not too biodegradable

Identify which structure/s below would form scum with magnesium and calcium ions.

i	~~~~~O^O^O^O^O^OH
ii	~~~~~⬡–⊖
iii	~~~~~⊖
iv	~~~~~N⁺~

A. i, ii and iv

B. ii and iii

C. ii only

D. iii only

Do NOT write in this area

17. A student performed flame tests on two solutions of unknown metal ions. Her results are shown below.

Solution A   Solution B

Select the row that correctly identifies the metal ions in Solution A and B respectively.

A. Calcium and sodium

B. Barium and calcium

C. Copper and barium

D. Calcium and copper

18. Consider the following.

$$HIn_{(aq)} \rightleftharpoons H^+ + In^-$$
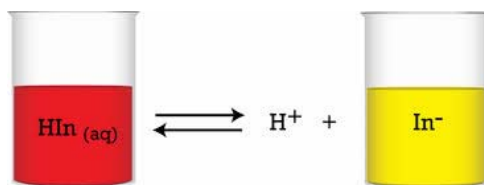
Choose the correct statement.

A. This is an example of a buffer system. A buffer is made up of a weak acid and its conjugate base. This system can resist a change in pH no matter how much acid or base is added.

B. This is an example of a buffer system. A buffer is made up of a strong acid and its conjugate base. This system can resist a change in pH no matter how much acid or base is added.

C. This is an example of a buffer system. A buffer is made up of a weak acid and its conjugate base. This system can resist only a small addition of an acid or base.

D. This is an example of a buffer system. A buffer is made up of a strong acid and its conjugate base. This system can resist only a small addition of an acid or base.

19. Which one of the following compounds is an isomer of $CH_3CH_2CH_2CH_2OH$?

    A. $CH_3CH_2CH_2CH_3$

    B. $CH_3CH(OH)CH_3$

    C. $CH_3CH_2CH_2CHO$

    D. $CH_3CH_2CHOHCH_3$

20. Darren performed a first-hand investigation to analyse the reversibility of the reaction for the cobalt chloride hexahydrate solid.

Below is a section of the SDS for cobalt chloride hexahydrate.

> H302 Harmful if swallowed.
> H317 May cause an allergic skin reaction.
> H334 May cause allergy or asthma symptoms or breathing difficulties if inhaled.
> H341 Suspected of causing genetic defects.
> H350 May cause cancer by inhalation.
> H360 May damage fertility.
> H410 Very toxic to aquatic life with long lasting effects.

Use the section of the SDS for cobalt chloride hexahydrate to determine which of the following safe work practices Darren should use for his first-hand investigation.

    i.   Wear safety goggles
    ii.   Turn fan onto the highest speed to move air around room
    iii.   Wear leather shoes
    iv.   Perform investigation in a fume cupboard
    v.   Use a dropper when transferring substance
    vi.   Dispose of substance down the sink and flush with water
    vii.   Wear disposable (chemically resistant) gloves

    A. i, iii, iv, vii

    B. i, ii, iii, v, vii

    C. i, ii, iii, iv, v, vi, vii

    D. i, iii, vii

HIGHER SCHOOL
CERTIFICATE
TRIAL EXAMINATION

Chemistry

Section II
Answer Booklet

80 marks
Attempt Questions 21 – 36
Allow about 2 hours and 25 minutes for this section

Instructions
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

- Show all relevant working in questions involving calculations.

- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering AND **indicate on your original question that your answer continues.**

- Write your student number at the front of every section in the space provided.

Please turn over

Question 21 (5 marks) **Marks**

a. Determine the pH of the resulting solution when 15 mL of 0.07 M hydrochloric acid is added to 14 mL of 0.09 M potassium hydroxide assuming 100% dissociation. **3**

b. Explain why equimolar solutions of carbonic acid and nitric acid have different pH values. **2**

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Question 22 (3 marks)   **Marks**

The following titration curve was obtained when 25 mL of 0.14 M oxalic acid $(COOH)_2$ was titrated against an unknown concentration of NaOH.

Oxalic acid is a diprotic acid with the following structural formula:
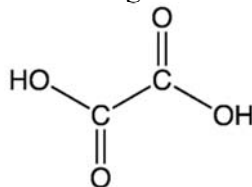
Titration Curve (oxalic acid/NaOH)
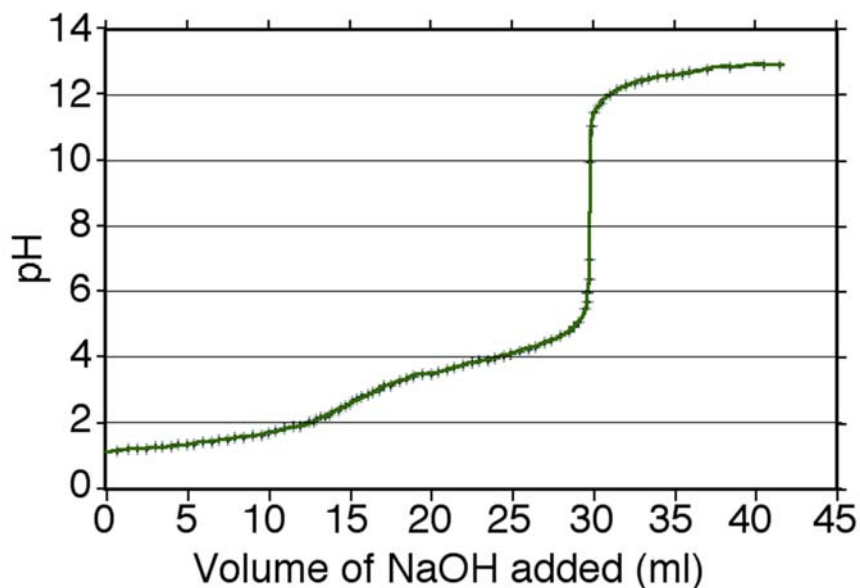
a. Write a balanced chemical equation for this reaction.   **1**

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b. From the graph, determine the end point of the reaction, and thus, calculate the
   concentration of NaOH.   **2**

The following is a table which shows the acid dissociation constants (K_a) of some acids:

TABLE 16.3 Acid-Dissociation Constants of Some Common Polyprotic Acids

Name	Formula	K_{a1}	K_{a2}	K_{a3}
Ascorbic	$H_2C_6H_6O_6$	8.0×10^{-5}	1.6×10^{-12}	
Carbonic	H_2CO_3	4.3×10^{-7}	5.6×10^{-11}	
Citric	$H_3C_6H_5O_7$	7.4×10^{-4}	1.7×10^{-5}	4.0×10^{-7}
Phosphoric	H_3PO_4	7.5×10^{-3}	6.2×10^{-8}	4.2×10^{-13}
Sulfurous	H_2SO_3	1.7×10^{-2}	6.4×10^{-8}	
Sulfuric	H_2SO_4	Large	1.2×10^{-2}	
Tartaric	$H_2C_4H_4O_6$	1.0×10^{-3}	4.6×10^{-5}	

Using equations, explain why phosphoric acid has values for K_{a1}, K_{a2} and K_{a3}, while carbonic acid only has values for K_{a1} and K_{a2}. **3**

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Question 24 (3 marks) **Marks**

Ethanol can be referred to as a biofuel.

Analyse the advantages of the bioethanol compared to ethanol fuels produced from fossil fuels. **3**

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Question 25 (2 marks)

A student has a 0.004 mol/L solution of perchloric acid ($HClO_4$) which completely ionises in solution. Determine the concentration of hydrogen ions in the solution if they dilute 150 mL of this solution to 1.85 L. **2**

Question 26 (5 marks)

In your studies you used a model to demonstrate dynamic equilibrium.

    a. Outline how you modelled dynamic equilibrium. **2**

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    b. Describe one limitation of your model. **1**

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    c. You are given a selection of resources (from textbooks, the Internet and Luke doing Yr 12 Chemistry at Sydney Tech) to help with developing a dynamic model. Outline how you would ensure that the secondary sources you use to create your model are accurate and reliable. **2**

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Question 27 (6 marks)   **Marks**

Maggie calculated the maximum concentration (saturation) of magnesium hydroxide dissolved in water was 9.24×10^{-4} grams per 100 mL of H_2O when measured at 25 °C.

a. Write a balanced equation to show magnesium hydroxide dissolved in water. Ensure that states are included.   **1**

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b. Write a solubility equilibrium expression for magnesium hydroxide in water.   **1**

c. Calculate the value of K_{sp} at 25°C for magnesium hydroxide.   **2**

d. Calculate the value of pOH for a saturated solution of magnesium hydroxide at 25°C.   **2**

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Question 28 (4 marks)

Marks

Outline the processes (*intramolecular and intermolecular bonding*) involved in the dissolution of sodium chloride in water. Include a labelled diagram to support your response.

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Question 29 (6 marks)   **Marks**

A student has a tablet containing iodide ions and an inert (non-reactive) water-soluble sugar used as a filler. They performed the following investigation:

A tablet is dissolved in 50.0 mL of distilled water, and an excess of 0.20 M $Pb(NO_3)_2$ $_{(aq)}$ is added to the solution. A yellow precipitate forms, which is then filtered, washed, and dried.

The data from the experiment is shown in the table below.

Mass of tablet containing iodine ions (g)	0.425
Mass of thoroughly dried filter paper (g)	1.462
Mass of filter paper + precipitate after first drying (g)	1.775
Mass of filter paper + precipitate after second drying (g)	1.699
Mass of filter paper + precipitate after third drying (g)	1.698

a. Write a balanced, net-ionic equation for the reaction.   **2**

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b. Calculate the number of moles of precipitate that is produced in the experiment.

                                                                    2

c. Calculate the percentage mass of I^- in the tablet.   **1**

d. Write an aim for their investigation.   **1**

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Excess copper (II) oxide and 100 mL of 3 M sulfuric acid are reacted in the reaction as
follows:

$$CuO_{(s)} + H_2SO_{4(aq)} \rightarrow CuSO_{4(aq)} + H_2O_{(l)}$$
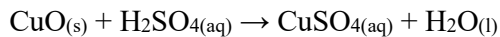
a. When this reaction was completed in a calorimeter, the temperature of the solution
    increased by 20 °C. Calculate the ΔH of this reaction, assuming that the mass of the
    solution is 100 g.   **2**

b. Can this reaction be classified as an acid/base (neutralisation) reaction? Justify your
    answer.   **2**

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Question 31 (9 marks)   **Marks**

Alice was performing an experiment to determine the K_{eq} of an iron (III) thiocynate equilibrium. Unfortunately for her, on the day of her experiment, the colourimeter was broken. Her instructor told her that instead of a colourimeter, she is to use an Atomic Absorption Spectrometer (AAS).

The following diagram is a schematic of AAS.
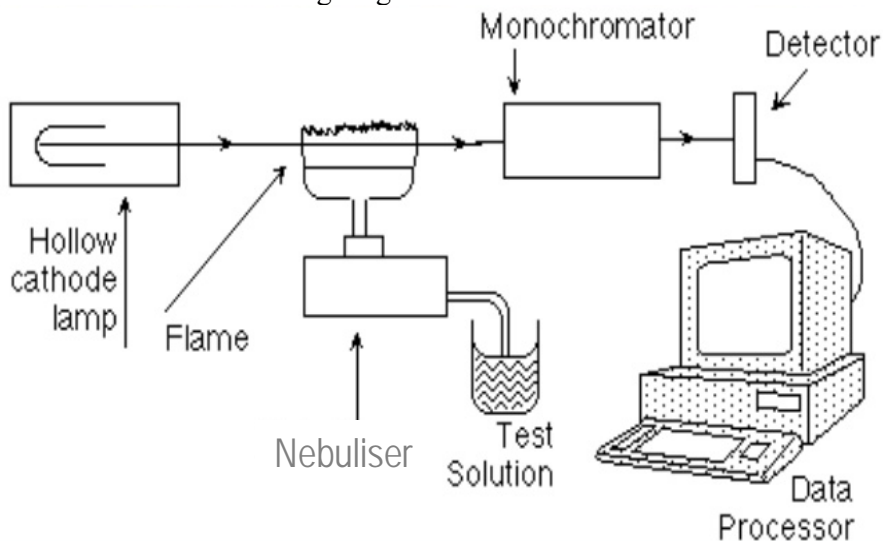
a. Outline the purpose of the nebuliser.   **1**

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b. Outline one limitation of AAS.   **1**

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Alice knew that before she ran her unknown, she had to create a calibration curve. To do this, she made up solutions of known concentrations of iron (III) thiocyanate.

The following is the data that she collected:

Absorbance	$[Fe(SCN)^{2+}]$ (mol/L)
0.42	0.001
0.69	0.0015
0.90	0.002
1.06	0.0025
1.35	0.003

Question 31 continues on page 22

c. Draw an appropriate calibration curve on the graph paper provided.
3
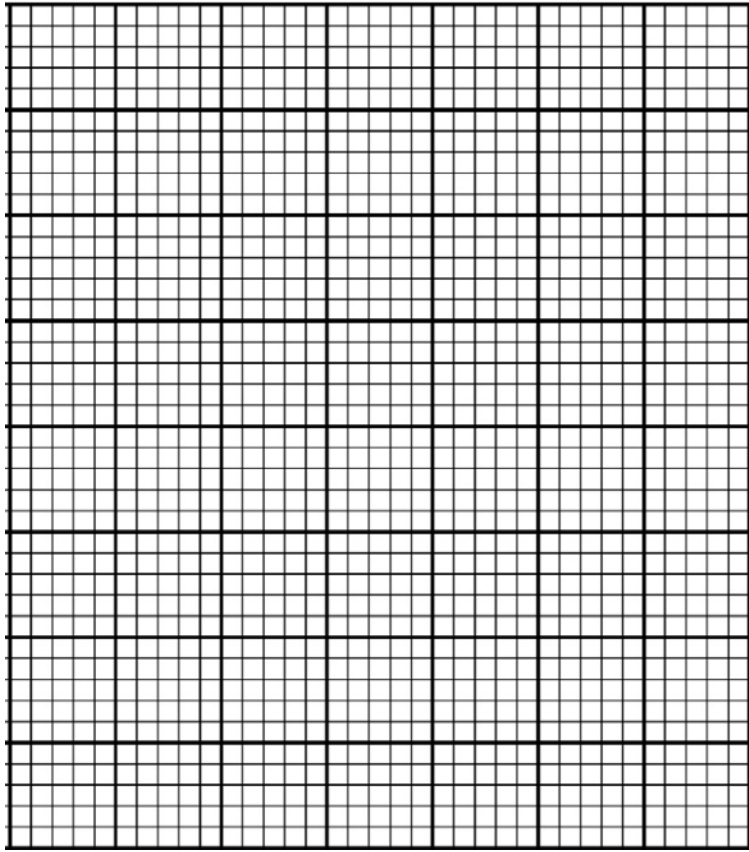
d. Alice placed her unknown solution into the AAS and found that it had an absorbance of 0.050. Determine the concentration of $Fe(SCN)^{2+}$ from your graph. Show all working on your graph.
1

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Question 31 continues on page 23

– 22 –

e. i. Alice originally combined 0.002 M of Fe^{3+} with 0.006 M of SCN^- to make the unknown solution. Write an equation for this reaction.   **1**

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ii. Calculate the K_{eq} of this reaction.   **2**

End of Question 31

Question 32 (3 marks)

Describe one process used by Aboriginal People to remove toxins from one of their named foods. Appropriately refer to solubility equilibrium and open/closed system in your response.

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Question 33 (4 marks)

The following graph illustrates the concentration of reactants and products over time.
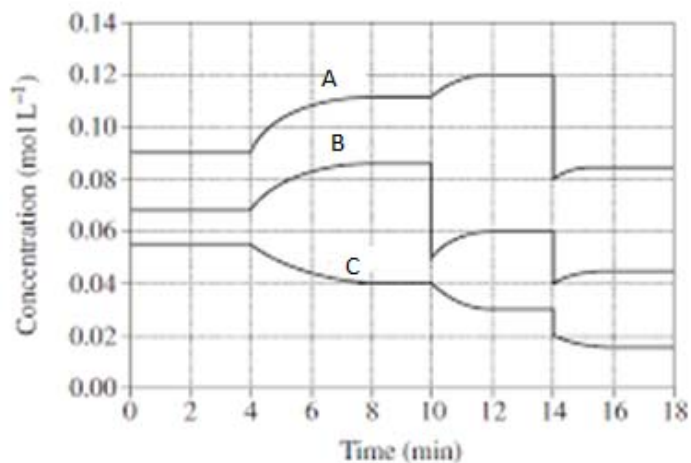
The general equation for the reaction is:

$$4A_{(g)} + 2B_{(g)} \rightleftharpoons C_{(g)} \qquad \Delta H \text{ is positive}$$

Analyse the graph to determine the changes that occurred to the system at 4, 10 and 14 minutes.

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The following molecule is a liquid fuel at 25°C. The heat of combustion for this fuel is 3330.63 kJ mol^{-1} and the standard molar entropy is 0.2589 kJ K^{-1} mol^{-1}.
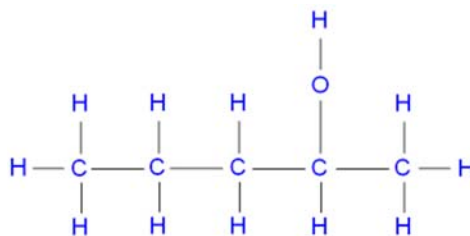
a.　Write a balanced chemical equation for the combustion of this liquid fuel in excess oxygen.　　**1**

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b.　Calculate the ΔG of this reaction, and thus, identify whether this system is an equilibrium or non-equilibrium system.　　**2**

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c.　Outline two safe handling practices you should follow when handling organic compounds.　　**2**

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Question 35 (9 marks)   **Marks**

a. Outline how a 250 mL of a 0.1 mol/L sodium hydrogen carbonate standard solution
    can be prepared in the laboratory.   **3**

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b. Identify the piece of equipment used in titration shown below: **1**

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Question 35 continues on page 28

c. Identify the uncertainty of measurement in this piece of equipment shown below.

1

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d. A student plans to perform a titration using 0.1 mol/L solution of sodium hydrogen carbonate and 0.05 mol/L solution of hydrochloric acid.

Identify the indicator they should use for this titration.   **1**

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e. Prior to titrating, she rinsed all required glassware with water three times. She then rinsed the conical flask with the base prior to transferring a 25 mL aliquot of the base ready for titrating.
    i.   Identify the error in her method.   **1**

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    ii. Explain whether the error you identified above is a systematic or random error.

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End of Question 35

Question 36 (9 marks)

One of the inquiry questions found in your syllabus asks: "What are the implications for society of chemical synthesis and design?"

Using your knowledge from any/all of the modules you have studied, evaluate the factors that need to be considered when designing an industrial chemical synthesis process. Include specific examples in your answer.

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End of Examination

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