

North Sydney Boys High School
Science Faculty
Year 12 Chemistry 2019
Assessment 3

General Instructions:**Reading time – 5 minutes****Working time – 2 hours 15 minutes (135 minutes)**

- Write using black or blue pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- This paper has three sections
- Write your student number at the top of every page

Total Marks - 75**Section A: Multiple Choice**

- 20 questions
- 20 marks

**Section B: Written Response
(Knowledge and Understanding)**

- 5 questions
- 30 marks

**Section C: Written Response
(Working Scientifically)**

- 5 questions
- 25 marks

Part A	/ 20	
Part B	/ 30	
Part C	/ 25	
Total Mark	/ 75	

This paper MUST NOT BE REMOVED from the examination room

Section A – Multiple Choice (20 marks):**Attempt questions 1 - 20****Use the answer grid to record your answer.****Question 1.**

A solution containing an unknown metal cation is mixed with a solution of calcium nitrate. A flame test was performed on the mixture and a brick red flame was observed.

Which of the following is the most appropriate conclusion from this test?

- (A) The unknown cation is calcium
- (B) The unknown cation is not copper
- (C) The unknown cation is barium
- (D) The unknown cation is not calcium

Question 2.

Which statement about a closed system is correct?

- (A) A closed system can exchange nothing with its surroundings
- (B) A closed system can only exchange energy with its surroundings
- (C) A closed system can only exchange matter with its surroundings
- (D) A closed system can only exchange matter and energy with its surroundings

Question 3.

Which of the following contains a coordinate covalent bond?

- (A) O₂
- (B) H₂O
- (C) O₃
- (D) CO₂

Question 4.

A group of students made a solution by adding 3.65 g of sodium carbonate to a 250 mL volumetric flask and making it up to the mark with distilled water.

The concentration of the sample is closest to:

- (A) 9.13 % W/W
- (B) 1.35 mol L⁻¹
- (C) 1.5 g per 100 g water
- (D) 15 ppm

Question 5.

How many isomers are there of 1,2-dichloroethene?

- (A) 0
- (B) 1
- (C) 2
- (D) 3

Question 6.

Hydrogen bromide reacts with propene to form:

- (A) Bromopropene and bromine
- (B) Bromopropene only
- (C) Bromopropane only
- (D) Bromopropane and bromine

Question 7.

A simple calorimeter was used to measure the enthalpy of combustion for butan-1-ol. The measured data was as follows:

Initial mass of spirit burner plus butanol (g)	285.35
Final mass of burner plus remaining butanol (g)	283.23
Volume of water in calorimeter (mL)	201.5
Initial water temperature (°C)	14.3
Final water temperature (°C)	48.8

The calculated enthalpy of combustion for butan-1-ol is closest to:

- (A) 100 J mol⁻¹
- (B) 100 kJ mol⁻¹
- (C) 400 kJ mol⁻¹
- (D) 1.00 MJ mol⁻¹

Question 8.

Which of the following compounds does not immediately react with bromine water, is soluble in water and reacts with sodium hydroxide?

- (A) $\text{CH}_3\text{CH}_2\text{COOH}$
- (B) $\text{CH}_3\text{CH}_2\text{OH}$
- (C) CH_2CHCH_3
- (D) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$

Question 9.

A compound has the formula;



What is the correct IUPAC name for this compound?

- (A) 3-bromo-2-fluorobut-1-ene
- (B) 2-bromo-3-fluorobut-3-ene
- (C) 2-fluoro-3-bromobut-1-ene
- (D) 3-fluoro-2-bromobut-3-ene

Question 10.

What is needed for the substitution reaction of ethane and chlorine?

- (A) A platinum catalyst
- (B) Concentrated sulfuric acid catalyst
- (C) A Ziegler-Natta catalyst
- (D) Ultraviolet light

Question 11.

Which statement relates most to NMR spectroscopy?

- (A) Valence electrons in metals atoms are excited, moving to a higher energy level
- (B) Nucleons are excited and move to a higher energy spin state
- (C) The mass of a charged particle will determine its trajectory in a magnetic field
- (D) Bonds in a molecule can absorb energy which results in them stretching

Question 12.

Question 12.

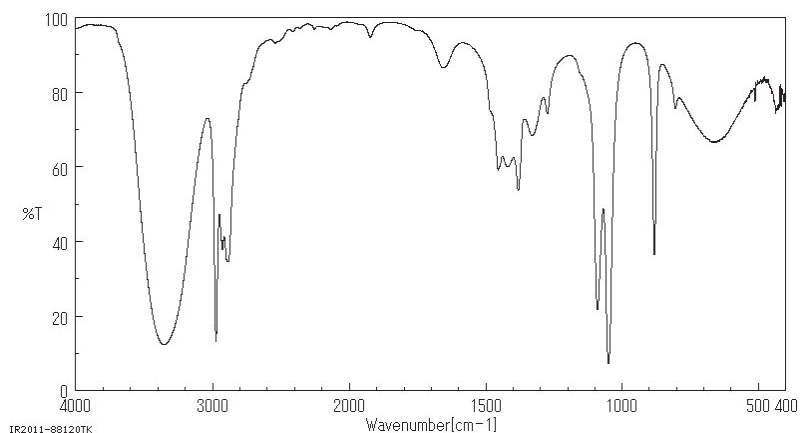
An experiment was performed to measure the heat of evaporation of liquids in a calorimeter. The results were consistently 40.5% below the expected values.

Which of the following best describes this experiment?

	valid	reliable	accurate
(A)	yes	no	no
(B)	no	no	yes
(C)	no	yes	no
(D)	yes	yes	yes

Question 13.

Shown below is the infra-red spectrum of an organic compound.



The compound that produced this spectrum is most likely an:

- (A) ester
- (B) aldehyde
- (C) alcohol
- (D) amide

Question 14.

An unknown solution was tested to determine which ions were present. The following results were obtained:

Test	Observations
Add dilute HCl	Gas produced that turns lime water cloudy
Add NH_4OH	A deep blue precipitate is formed

Which ions are present in this solution?

- (A) copper (II) oxide
- (B) copper (II) carbonate
- (C) barium hydroxide
- (D) barium oxide

Question 15.

A substance that could be formed as a product when a polysaccharide undergoes enzyme-catalysed hydrolysis is:

- (A) $\text{C}_6\text{H}_{12}\text{O}_6$
- (B) H_2O
- (C) $\text{CH}_3\text{CH}_2\text{OH}$
- (D) CO_2

Question 16.

The temperature at which a particular organic compound gives off sufficient vapour to ignite in air is called:

- (A) Ignition point
- (B) Flashpoint
- (C) Ignition temperature
- (D) Spontaneous combustion temperature

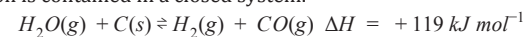
Question 17.

Equilibrium is reached when:

- (A) The concentration of products is constant
- (B) The forward and reverse reactions have stopped
- (C) The concentration of reactants and products are equal
- (D) The forward and reverse reactions continue at the same rate

Question 18.

The following reaction is contained in a closed system.



Which of the following situations will not affect the equilibrium position of this reaction?

- (A) The temperature of the system is decreased
- (B) Hydrogen is removed from the system
- (C) Carbon is added to the system
- (D) The pressure of the system is increased

Question 19.

Glucose was fermented in a reaction vessel overnight while held at 25 °C and 100 kPa. The gas produced in the investigation was collected in a gas jar. The investigation produced the following results:

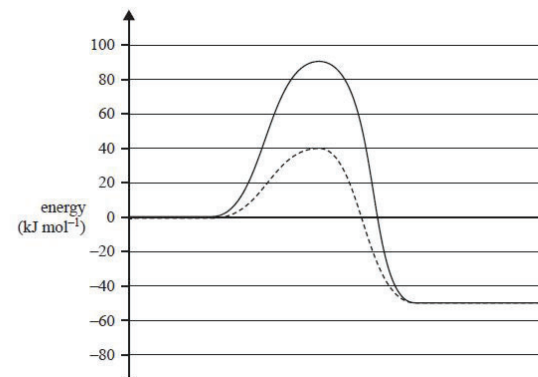
Initial mass of reaction vessel (g)	264.65
Final mass of reaction vessel (g)	262.16

The volume of gas produced by this investigation would be closest to:

- (A) 1.0 L
- (B) 0.1 L
- (C) 2.0 L
- (D) 0.5 L

Question 20.

The following diagram shows the energy profile for the same reaction both with and without a catalyst.



Which of the following corresponds best to this reaction?

	Activation energy - uncatalysed reaction E_a (kJ mol ⁻¹)	Heat of Reaction - catalysed reaction ΔH (kJ mol ⁻¹)
(A)	90	-140
(B)	40	-90
(C)	90	-50
(D)	40	-90

Attempt questions 21 - 25.

Use the space provided to answer the following questions.

Question 21 (6 marks)

The position of the hydroxyl function group in an alcohol will determine how it can be oxidised.

- (a) Outline, using equations, the oxidation reactions for a primary, secondary and tertiary alcohol 3

[illegible]

Question 21 continues on the following page

Question 21 (continued)

- (b) Starting from the oxidation and reduction half equations, write an equation to show the oxidation of a secondary alcohol with potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$). 2

[illegible]

- (c) Identify the observations you would expect from the reaction of a secondary alcohol with potassium dichromate to confirm that the oxidation has occurred. 1

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Student Number: _____

Student Number: _____

Question 22 (7 marks)

Biofuels have been developed in response to concerns about our continued use of fossil fuels. A number of significant steps have been taken to produce biofuels for use in vehicle engines.

Compare the impact on society and the chemistry involved in the production of both ethanol based biofuels derived from plant cellulose and biodiesel derived from vegetable oils.

[illegible]

Question 22 continues on the following page

Question 23 (7 marks)

$$COCl_2(g) \rightleftharpoons CO(g) + Cl_2(g)$$

- 2

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- 2

Compound	Enthalpy of Formation $\Delta H_f^\circ \text{ (kJ mol}^{-1}\text{)}$	Entropy $\Delta S^\circ \text{ (JK mol}^{-1}\text{)}$
Cl_2	0	233.08
CCl_2O	-209.5	283.8
CO	-110.53	197.66
CO_2	-393.52	213.79

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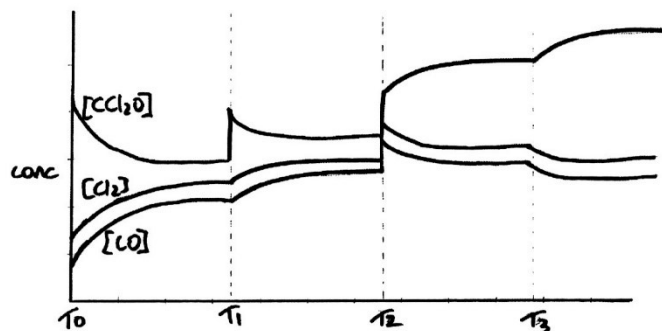
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Question 23 continues on the following page

- (c) The following shows the concentration of the species of this reaction as 3 changes were made to the system. The changes included a decrease in volume, a decrease in temperature and the addition of additional phosgene.



Justify which change occurred at T1, T2 and T3 AND identify whether this reaction is endothermic or exothermic.

3

Question 24 (6 marks)

Polystyrene is a common polymer with a wide variety of uses.

- (a) Compare the structure, properties and uses of polystyrene with one other addition polymer.

3

Question 24 continues on the following page

Question 24 (continued)

- (b) The following table shows the structure of some simple amino acids.

Student Number: _____

Amino acid	Structural formula
General formula	$\text{NH}_2\text{CHRCOOH}$
glycine	$\text{NH}_2\text{CH}_2\text{COOH}$
alanine	$\text{NH}_2\text{CH}(\text{CH}_3)\text{COOH}$

Compound	Boiling point (°C)
butane	-1.0
methyl propanoate	79.8
butan-1-ol	117.7
butanoic acid	163.5

(a) Provide an explanation for the trend in boiling points for these four compounds.

3

4

Section C – Written Response - Working Scientifically (25 marks):

Attempt questions 26 - 30.

Use the space provided to answer the following questions.

solutions.

Two samples of pond water were also analysed and the results shown in the table.

- | Sample | Concentration (ppm) | Absorbance |
|------------|---------------------|------------|
| Control | 0.0 | 0.000 |
| Standard 1 | 5.0 | 0.248 |
| Standard 2 | 10.0 | 0.482 |
| Standard 3 | 15.0 | 0.751 |
| Standard 4 | 20.0 | 0.958 |
| Sample 1 | | 0.764 |
| Sample 2 | | 0.986 |

[illegible]

- (a) Graph the standard curve for the chromium solutions on the following grid. 4

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85															

Question 27 (7 marks)

Question 27 (continued)

(b) Using your graph from part (a), determine the concentration of sample 1. **1**

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(c) Propose a strategy for obtaining a valid result for sample 2. **2**

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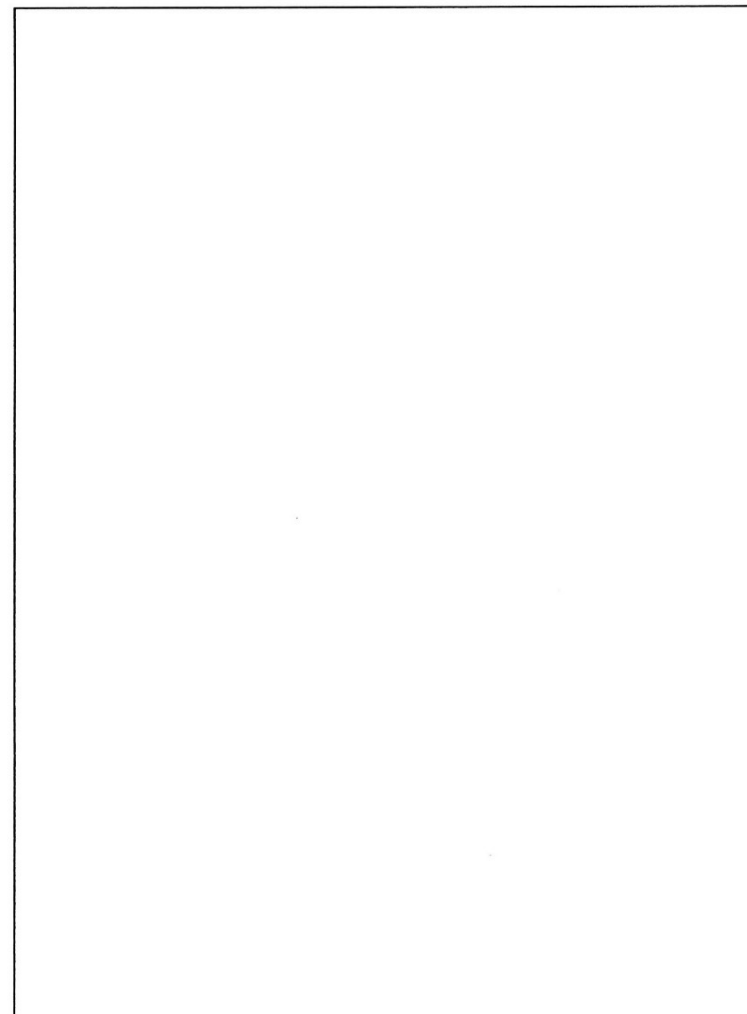
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Question 28 (5 marks)

Using a series of annotated diagrams, explain the cleaning behaviour of soaps and detergents.



Question 29 (3 marks)

The mass spectrum of a sample of iron shows four peaks. The data is included in the table below:

m/z	54	56	57	58
Abundance (%)	5.845	91.754	2.119	0.286

- (a) From this data calculate the relative atomic mass of iron.

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- (a) Suggest an explanation why your result from part (a) does not match the accepted value.

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Question 30 (4 marks)

Design a flowchart to illustrate the reaction steps involved in going from glucose to polyethylene. Show all of the steps and reactions involved.

End of Test

2019 Chemistry Trial Solutions

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

Question 21 (6 marks)

The position of the hydroxyl function group in an alcohol will determine how it can be oxidised.

- (a) Outline, using equations, the oxidation reactions for a primary, secondary and tertiary alcohol 3

Criteria	Mark
All information is correct and equations are correct. Equations were written as structural or condensed structural. Primary alcohol need to state that it oxidised to an aldehyde then carboxylic acid. Secondary oxidised to ketone Tertiary alcohol no oxidation	3
An error such as everything is correct and had equations but used molecular formula instead of structural or condensed structural OR Used [O] to indicate oxidant. Needed to name the specific oxidant. OR Everything else is right but stated that dichromate was a catalyst. Above are just examples there are many other one errors that could have lost you the mark.	2
Many errors but wrote something relevant	1

Note from marker: Many students stated that dichromate is a catalyst. It is not it is the oxidant. And DO NOT use [O]. I know that it is written like that on the wikipedia site about alcohol oxidation but it doesn't show you understand and it won't get you marks in the HSC.

- (b) Starting from the oxidation and reduction half equations, write an equation to show the oxidation of a secondary alcohol with potassium dichromate ($K_2Cr_2O_7$). 2

Criteria	Mark
Both half equations present and correct	2
Had a correct half equation	1

- (c) Identify the observations you would expect from the reaction of a secondary alcohol with potassium dichromate to confirm that the oxidation has occurred. 1

1 mark for stating that the solution changes colour from orange to green. Needed to be specific. If you were not then you got 0

Question 22 (7 marks)

Biofuels have been developed in response to concerns about our continued use of fossil fuels. A number of significant steps have been taken to produce biofuels for use in vehicle engines.

Compare the impact on society and the chemistry involved in the production of both ethanol based biofuels derived from plant cellulose and biodiesel derived from vegetable oils.

Criteria	Marks
<ul style="list-style-type: none">Thorough and correct description of the chemistry involved in the production of bioethanol and biodiesel.Correct and thorough description of the impacts on society and bioethanol and biodiesel are compared to each other NOT to fossil fuels. If you got a 6 that means there was a slight error with the chemistry perhaps you left out the catalyst or something slight.	6-7
Good description of chemistry but there is information missing. Impacts on society are mentioned some soundly described. There is an attempt to compare bioethanol and biodiesel.	4-5
Chemistry mentioned about both biodiesel and bioethanol but only one is described adequately. Some impacts on society (some dubious) are outlined and there is little comparison to each other. Comparison was mainly to fossil fuels.	2-3
Written something relevant	1

Question 23 (7 marks)

Phosgene (CCl_2O) is a poisonous gas that dissociates at high temperature into two other poisonous gases, carbon monoxide and chlorine.



- (a) Phosgene at 15.6 kPa is allowed to come to equilibrium in a fixed volume at 600°K. 2

If the equilibrium composition of carbon monoxide at this temperature is measured to be 2.14 kPa, calculate the equilibrium constant for this system.

Criteria	Marks
Correct calculations and answer	2
Did something correct	1

Note from marker: Pressure K_{eq} is not equivalent to K_{eq} based on concentration however, if you wrote the Equilibrium equation in using concentrations i gave it to you. But remember $P_{K_{eq}}$ has a slightly different equation, concentration symbols are not used..

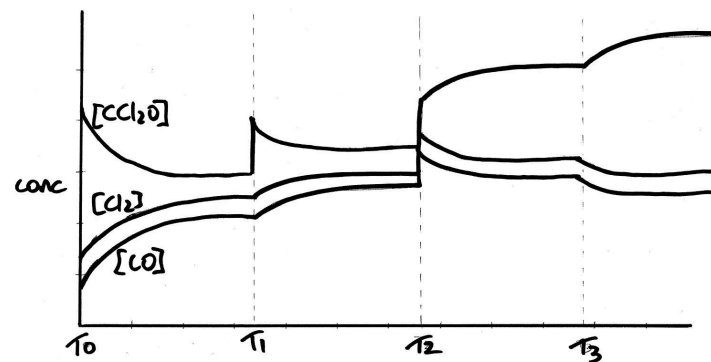
- (b) The following table shows thermochemistry data for some compounds at 298 °K, 100 kPa 2

Compound	Enthalpy of Formation $\Delta H_f^\circ \text{ gas } (kJ \text{ mol}^{-1})$	Entropy $\Delta S^\circ \text{ gas } (JK \text{ mol}^{-1})$
Cl_2	0	233.08
CCl_2O	-209.5	283.8
CO	-110.53	197.66
CO_2	-393.52	213.79

Using this data, calculate the Gibbs Free Energy for this reaction at 25°C, 100 kPa.

Criteria	Marks
Correct calculations and answer	2
Did something correct	1

- (c) The following shows the concentration of the species of this reaction as 3 changes were made to the system. The changes included a decrease in volume, a decrease in temperature and the addition of additional phosgene.



Justify which change occurred at T1, T2 and T3 **AND** identify whether this reaction is endothermic or exothermic. 3

Criteria	Mark
Three good justification and stating that the reaction is endothermic. I didn't accept as a justification "and because it is the last one T3 must be temperature". You had to describe what the graph was doing which indicates that it was temperature.	3
Two strong justifications and correct endothermic OR Three strong justifications but stated the reaction was exothermic.0	2
Wrote something that was relevant	1

Question 24 (6 marks)

Polystyrene is a common polymer with a wide variety of uses.

- (a) Compare the structure, properties and uses of polystyrene with one other addition polymer. 3

Criteria	Marks
1. Shows the chemical structure of polystyrene and another polymer, describes the contribution of intermolecular forces and packing. 2. Establish relationship between structure and properties for both polymers 3. Establish relationship between properties and uses for both polymers	
3 criteria high order	3
One criteria missing or in error or poorly expressed	2
One criteria met	1

(b) The following table shows the structure of some simple amino acids.

Amino acid	Structural formula
General formula	$\text{NH}_2\text{CHRCOOH}$
glycine	$\text{NH}_2\text{CH}_2\text{COOH}$
alanine	$\text{NH}_2\text{CHCH}_3\text{COOH}$

Amino acids are the building blocks for life being joined together to form polypeptides and proteins in the cells of living organisms. The reaction between two amino acids forms a peptide bond, which has some similarities to the bonds involved in the formation of an amide and an ester.

Compare the formation of the peptide bond with the formation of both the amide and ester bonds.

3

Criteria	Marks
Shows diagram for amide and ester linkage Identifies all as condensation reactions with one example reaction (water eliminated) Establish similarities between amide and peptide link Establish differences between ester and peptide link	
3 criteria high order	3
One criteria missing or in error or poorly expressed	2
One criteria met	1

Question 25 (4 marks)

The boiling points of four compounds are shown below:

Compound	Boiling point (°C)
butane	-1.0
methyl propanoate	79.8
butan-1-ol	117.7
butanoic acid	163.5

(a) Provide an explanation for the trend in boiling points for these four compounds.

4

Criteria	Marks
Identify that boiling point a measure of strength of intermolecular forces Explain structure and bonding of alkane, ester, alkanol and alcanoic acid Identify different intermolecular forces present in each compound Establish ranking of strengths of intermolecular forces	
4 criteria high order	4
4 criteria sound or 3 criteria high order	3
4 criteria basic or 3 criteria sound or 2 criteria high order	2
1 criteria attempted	1

Note:
Definition of H Bond is an H attached to O, N or F. The carboxylic acids can only form one H Bond, however the very polar O atom will participate in H Bonding of other molecules.

Section C – Written Response - Working Scientifically (25 marks):

Attempt questions 26 - 30.

Use the space provided to answer the following questions.

Question 26 (6 marks)

During your Chemistry course, you performed a first hand investigation to produce an ester.

(a) Outline the risks associated with this investigation and the safety procedures you adopted to minimise the impact of these risks.

3

Criteria	Marks
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3 risks identified and addressed appropriately	3
2 risks identified and addressed appropriately	2
1 risk identified	1

Note:
The risks that should be identified are those that are peculiar to esterification.
Wearing goggles in the lab is a standard procedure regardless of the investigation.

(b) Use a diagram to show how the process of refluxing was performed.

3

Criteria	Marks
Complete diagram, complete labels	3
One error in diagram or labels	2
Key pieces of equipment identified	1

Question 27 (7 marks)

The following AAS data shows the absorbance measured for 4 standard chromium solutions.

Two samples of pond water were also analysed and the results shown in the table.

Sample	Concentration (ppm)	Absorbance
Control	0.0	0.000
Standard 1	5.0	0.248
Standard 2	10.0	0.482
Standard 3	15.0	0.751
Standard 4	20.0	0.958
Sample 1		0.764
Sample 2		0.986

(a) Graph the standard curve for the chromium solutions on the following grid.

4

Criteria	Marks
All parts of graph correct (see part b)	4
Trivial error in graph	3
Multiple errors in graph	2
Serious problem	1

(b) Using your graph from part (a), determine the concentration of sample 1.

1

Criteria	Marks
Show how data is derived from graph (see part a). Answer is reasonable and has appropriate significant figures	1

(c) Propose a strategy for obtaining a valid result for sample 2.

2

Criteria	Marks
Identify an effective strategy with procedure	2
Identify an effective strategy	1
Strategy does not provide valid result	0

Question 28 (5 marks)

Using a series of annotated diagrams, explain the cleaning behaviour of soaps and detergents.

Criteria	Marks
Shows chemical structure with distinction between soaps and detergents. Shows at least THREE examples (soap, cationic/anionic/non-ionic detergents). Clearly shows how soap/detergent is able to perform its role in cleaning with an explanation based on the intermolecular forces. Diagrams/annotations convey a succinct and complete story	
4 criteria high order	5

4 criteria sound or 3 criteria high order	4
4 criteria basic or 3 criteria sound or 2 criteria high order	3
3 criteria basic or 2 criteria sound or 1 criteria high order	2
1 relevant point	1

Question 29 (3 marks)

The mass spectrum of a sample of iron shows four peaks. The data is included in the table below:

m/z	54	56	57	58
Abundance (%)	5.845	91.754	2.119	0.286

- (a) From this data calculate the relative atomic mass of iron.

2

Criteria	Marks
Correctly shows working to calculate correct answer (to 3 significant figures)	2
One error in working/answer or incorrect sig figs	1
Incorrect answer and lack of working	0

- (a) Suggest an explanation why your result from part (a) does not match the accepted value.

1

The accepted value = data sheet value, is the best estimate average for the iron on the whole Earth. Any individual sample of iron may not match this value exactly.

Criteria	Marks
Propose a reasonable explanation	1
No appropriate suggestion offered	0

Question 30 (4 marks)

Design a flowchart to illustrate the reaction steps involved in going from glucose to polyethylene. Show all of the steps and reactions involved.

Criteria	Marks
Clearly shows input, process and output from each step in the flowchart. Shows all relevant equations(balanced, states, catalysts) Follows a realistic, workable sequence of steps from beginning to end.	

All criteria met	4
One missing or incorrect step in flow chart OR poor quality/readability	3
As in (3) with additional error/missing step	2
One correct step or equation	1

End of Test