
Student Number

Barker College

2020 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

PM WEDNESDAY 12th AUGUST

85 copies

Section I - Multiple Choice
Choose the best response and fill in the response oval completely

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Start Here →

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

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2020 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

Staff Involved:

- AXC
- NJD
- DLM*
- RJP
- KMT

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PM WEDNESDAY 12th AUGUST

TIME: 3 hours

General Instructions:

- Reading time - 5 minutes
- Working time - 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A separate Periodic Table and Data Sheet are provided with this paper
- For questions in Section II, show all relevant working in questions involving calculations

Total marks:
100

Section I - 20 marks (pages 3 - 9)

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

Section II - 80 marks (pages 11 - 30)

- Attempt Questions 21 - 34
- Allow about 2 hour and 25 minutes for this section

Section I: Multiple Choice

20 marks
Attempt Questions 1 – 20
Allow about 35 minutes for this part
Use the multiple-choice answer sheet

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.

A ● B ⊗ C ○ D ○

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1. A system which has both mass and energy transfer across the boundary is called a(n):

   A. Closed System

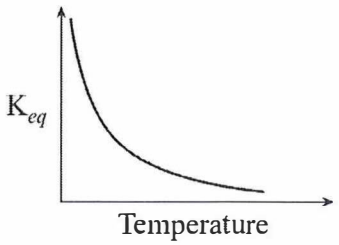
   B. Open System

   C. Isolated System

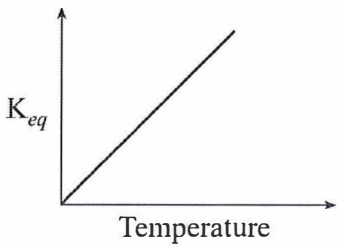
   D. None of the above

2. The relationship between Keq and temperature for an exothermic reaction is represented by

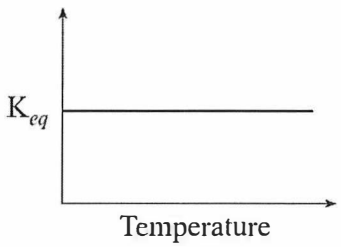
A.



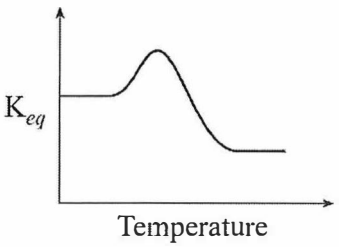
B.



C.



D.



3. The solubility of $Mn(IO_3)_2$ is 4.8×10^{-3} M. What is the value of Ksp ?

   A. 1.1×10^{-7}

   B. 4.4×10^{-7}

   C. 7.1×10^{-6}

   D. 1.1×10^{-1}

4. When comparing 1.0 M solutions of bases, the base with the lowest $[OH^-]$ is the:

   A. weakest base and it has the largest K_b value.

   B. strongest base and it has the largest K_b value.

   C. weakest base and it has the smallest K_b value.

   D. strongest base and it has the smallest K_b value.

5. Consider the following solubility data.

Compound	*Solubility constant at 25°C*
$CuSO_4$	2.28×10^{-2}
$BaSO_4$	1.08×10^{-10}
$CaSO_4$	4.93×10^{-5}

The order of cation concentration, from highest to lowest, is:

A. $[Ba^{2+}] > [Ca^{2+}] > [Cu^{2+}]$

B. $[Ca^{2+}] > [Cu^{2+}] > [Ba^{2+}]$

C. $[Cu^{2+}] > [Ca^{2+}] > [Ba^{2+}]$

D. $[Cu^{2+}] > [Ba^{2+}] > [Ca^{2+}]$

6. What is the advantage of a biofuel compared to a fuel derived from fossil fuels?

A. No energy is used to extract and isolate a biofuel from its source.

B. The amount of energy per mole is greater for the biofuel compound.

C. Only the biofuel is produced naturally in an endothermic reaction.

D. The biofuel can be replenished quickly using natural processes

7. A sample of compound M is analysed in a mass spectrometer where it forms the molecular ion M^+ according to:

$$M + e^- \rightarrow M^+ + 2e^-$$

Some of the molecular ions fragment as follows.

$$M^+ \rightarrow X^+ + Y \text{ and}$$

$$M^+ \rightarrow X + Y^+$$

The mass spectrum would show peaks due to the species

A. M^+, X, X^+, Y and Y^+ only.

B. M^+, X^+ and Y^+ only.

C. X^+ and Y^+ only.

D. X and Y only.

8. Pure water self-ionises as shown by the equation:

$$2H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$

The following table shows the value of the ionisation constant (Kw) of pure water at various temperatures and at a constant pressure

Temperature (°C)	0	25	50	75	100
K_w	1.1×10^{-15}	1.0×10^{-14}	5.5×10^{-14}	2.0×10^{-13}	5.6×10^{-13}

Given this data, which one of the following statements about pure water is correct?

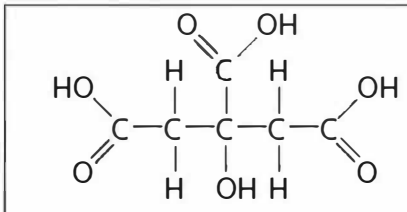
A. The $[OH^-]$ will decrease with increasing temperature.

B. The $[H_3O^+]$ will increase with increasing temperature.

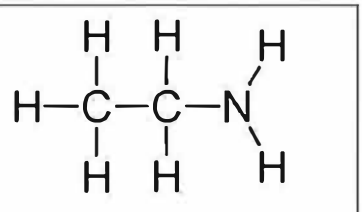
C. Its pH will increase with increasing temperature.

D. Its pH will always be exactly 7 at any temperature.

9. Consider the following two compounds.



Compound X



Compound Y

Which of the following best describes the properties of compounds X and Y?

A. Both compounds are acidic.

B. Both compounds are basic.

C. Compound X is basic and compound Y is acidic.

D. Compound X is acidic and compound Y is basic.

Use the following information to answer Questions 10 and 11.

Hydrogen is produced on an industrial scale from methane. The equation for the reaction is

$$2H_2O_{(g)} + CH_{4(g)} \rightleftharpoons CO_{2(g)} + 4H_{2(g)}$$

10. The expression for the equilibrium constant for the reverse reaction is:

A. $K = \dfrac{[H_2O]^2\,[CH_4]}{[H_2]^4\,[CO_2]}$

B. $K = \dfrac{[H_2]^4\,[CO_2]}{[H_2O]^2\,[CH_4]}$

C. $K = \dfrac{[H_2O]\,[CH_4]}{[H_2]\,[CO_2]}$

D. $K = \dfrac{4[H_2]\,[CO_2]}{2[H_2O]\,[CH_4]}$

11. If the temperature remains constant and the volume of the equilibrium system is halved, the immediate concentration of hydrogen will:

A. increase.

B. decrease.

C. not change.

D. decrease then increase.

12. Infrared spectroscopy detects frequencies of infrared light that are absorbed by a molecule. These absorptions are based on

A. movement of electrons between molecular energy levels.

B. movement of electrons between different atomic energy levels.

C. bending or stretching of covalent bonds in molecules.

D. absorption of radiation by nuclei placed in a magnetic field.

13. Carbon tetrachloride, CCl_4 is often used as a solvent in chemistry labs. Which statement is ***false*** about CCl_4?

A. It is a non-polar molecule.

B. Its main intermolecular forces are dispersion forces.

C. It has a tetrahedral shape.

D. It is the product of an addition reaction between methane and chlorine in the presence of UV light.

14. Which of the indicators listed in the table below would be ***most*** suitable for use during the titration of ammonia with hydrochloric acid?

Indicator	*pH*									
	0-4		*5-6*	*7*	*8-10*		*11-14*			
Litmus	red		red	purple	blue		blue			
Methyl Orange	red	orange	yellow	yellow	yellow		yellow			
Phenolphthalein	colourless		colourless	colourless	pink	red	red			

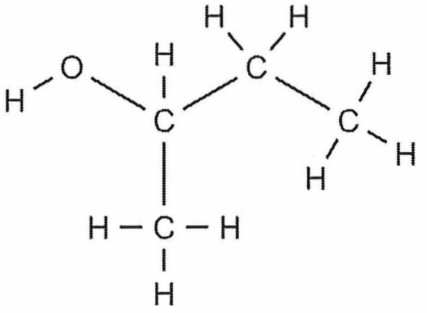
A. Methyl orange

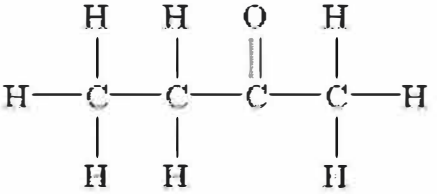
B. Litmus

C. Phenolphthalein

D. All three indicators would be equally suitable.

15. What is the correct relationship between the two molecules shown below?





A. They are functional group isomers

B. They are positional isomers

C. They are chain isomers

D. There is no relationship

16. Which combination could you use to prepare a buffer solution?

A. CH_3COONa and $HCOONa$

B. $NaNO_3$ and HNO_3

C. Na_2SO_4 and H_2SO_4

D. CH_3COONa and CH_3COOH

17. Which one of the following statements about 10.0 mL of 0.10 M HCl and 10.0 mL of 0.10 M CH_3COOH solutions is true?

A. Each solution will have the same electrical conductivity.

B. Each solution will react completely with 10.0 mL of 0.10 M NaOH solution.

C. Each solution will react at the same rate with 1.00 g of magnesium ribbon.

D. The concentration of H_3O^+ ions will be greater in the CH_3COOH solution.

18. A student performed an experiment in which 100 mL of water was heated by burning methanol in a spirit burner. What is the maximum change in temperature of the water when 0.500 g of methanol is completely combusted? (Assume all heat from the flame is absorbed into the water). The enthalpy of combustion of methanol is -726 kJ/mol.

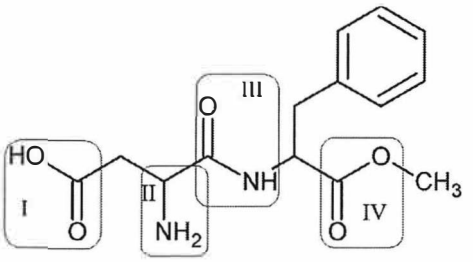
A. 0.027 °C

B. 1.74 °C

C. 27.1 °C

D. 36.3 °C

19. Aspartame is an artificial sweetener 200 times sweeter than sucrose. It is commonly used as a sugar substitute in foods and beverages. Its chemical structure is shown below.



The names of the functional groups labelled I, II, III and IV are:

	I	*II*	*III*	*IV*
A	Hydroxyl	Amine	Amide	Carbonyl
B	Carboxyl	Amine	Amide	Ester
C	Carboxyl	Carbonyl	Ammonia	Ester
D	Carboxyl	Amide	Amine	Carbonyl

20. How would the concentration of $Pb^{2+}_{(aq)}$ ions in equilibrium with $PbI_{2(s)}$ be affected if the concentration of $I^-_{(aq)}$ ions were doubled?

A. no change

B. increased by a factor of 2

C. decreased by a factor of 2

D. decreased by a factor of 4

End of Section I

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2020 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

Section II

Answer Booklet

80 marks

Attempt Questions 21 - 34

Allow about 2 hour 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.

Question 21 (4 marks)

A student takes a 50.0 mL sample from a saturated solution of silver chloride which was kept at 25°C.

(a) Write an equilibrium equation for solid silver chloride and its ions in solution. **1**

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(b) Calculate the mass of silver ions in the 50.0 mL sample. **3**

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Question 22 (3 marks)

Sodium hydrogen carbonate ($NaHCO_3$) is an amphiprotic compound.

(a) Write TWO net ionic equations showing its amphiprotic behaviour. **2**

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(b) Identify ONE conjugate acid-base pair from your equations. **1**

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Student Number

Question 23 (4 marks)

Hydrofluoric acid is a weak acid. The pH of a 0.025 M solution of hydrofluoric acid is 2.39.

(a) Calculate the Ka of the hydrofluoric acid. **2**

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(b) Calculate the pKa of the hydrofluoric acid. **1**

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(c) Calculate the percentage dissociation of the hydrofluoric acid. **1**

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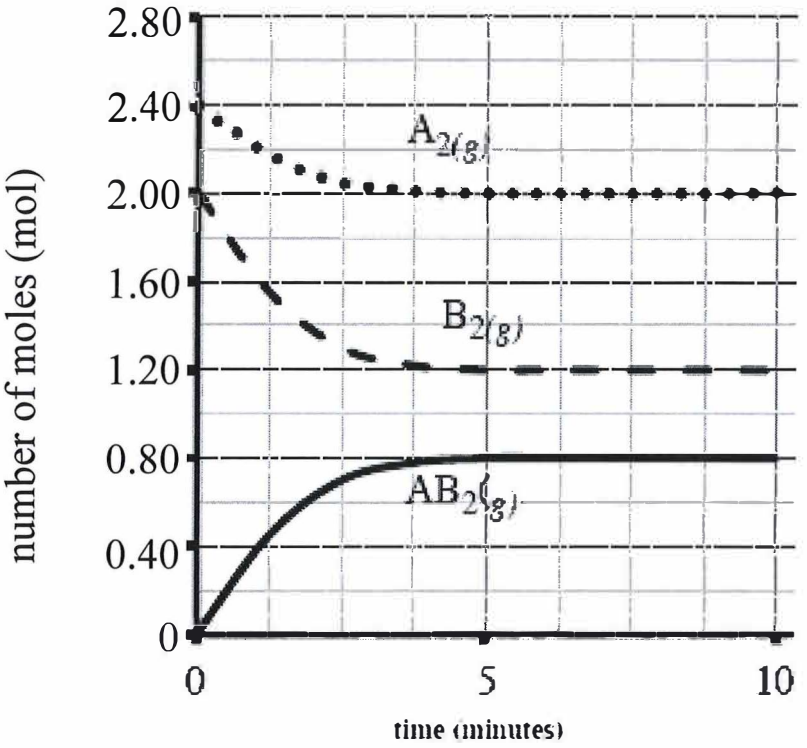
Question 24 (7 marks)

(a) Consider the following reaction that is taking place in a 2.00 L closed reaction flask at 25°C:

$$A_{2\,(g)} + 2B_{2\,(g)} \rightleftharpoons 2AB_{2\,(g)}$$

The following graph represents the changes in the number of moles of each gas in the flask over the first 10 minutes



(i) Using data from the graph, determine the value of the equilibrium constant (Keq) for the reaction. **3**

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Question 24 continues on page 15

Student Number

Question 24 (continued)

(ii) At a time of 15 minutes, some $B_{2\,(g)}$ was removed from the system. At 20 minutes, the contents of the reaction flask were analysed and the following data were obtained.

$$[A_2] = 1.05 \text{ mol } L^{-1}$$
$$[B_2] = 0.40 \text{ mol } L^{-1}$$
$$[AB_2] = 0.30 \text{ mol } L^{-1}$$

Determine if the system has reached equilibrium at 20 minutes and describe the rates of the forward and reverse reactions at this time?

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(b) Consider the equilibrium system involving the oxidation of nitric oxide

$$2NO_{(g)} + O_{2\,(g)} \rightleftharpoons 2NO_{2\,(g)} \qquad \Delta H = -556kJ$$

If the temperature was increased at time t, determine the effect on the position of equilibrium and complete the graph to show how the change will affect the concentration of reactants and product. **2**

(i) Effect on equilibrium position:

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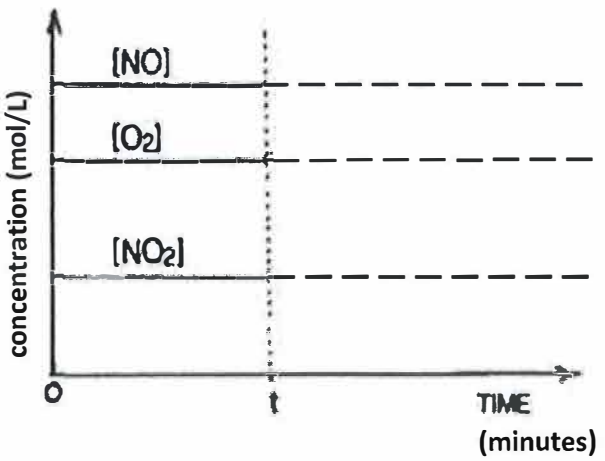
(ii)



Question 25 (7 marks)

A pharmaceutical manufacturer claims that their pain-relieving tablets contain 100% aspirin. To determine the actual percentage by mass of aspirin in an aspirin tablet, the following procedure, involving a back titration, was used.

Step 1: Three aspirin tablets, each with a mass of 300.0 mg, were crushed and dissolved in excess sodium hydroxide solution. Exactly 100.0 mL of 0.204 mol L^{-1} solution of sodium hydroxide was used. The mixture was boiled to ensure complete reaction.

Step 2: The excess sodium hydroxide solution was titrated with hydrochloric acid as follows: 20.0 mL of the solution from step 1 was pipetted into a conical flask and 0.125 mol L^{-1} hydrochloric acid was placed in the burette. The indicator, phenolphthalein, was used and an average titre of 17.89 mL of hydrochloric acid was required to reach the end-point.

(a) Calculate the number of moles of sodium hydroxide added in step 1. **1**

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(b) Calculate how many moles of sodium hydroxide reacted with the aspirin. **3**

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Question 25 continues on page 17

Student Number

Question 25 (continued)

(c) Each aspirin molecule requires two hydroxide ions for complete reaction. Calculate the percentage by mass of aspirin in one aspirin tablet. (The molar mass of aspirin is 180.154 g mol^{-1}.) **3**

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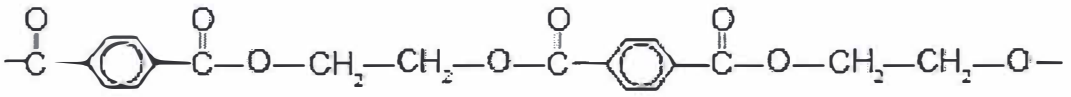
End of Question 25

Question 26 (8 marks)

Dacron is the trade name for a common polyester used in making clothes and water bottles. Part of its structural formula is given below:



(a) Draw the structural formula for the two monomers that react to form this polymer. **2**

Monomer one:

Monomer two:

(b) Name the other product of this polymerisation reaction. **1**

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Question 26 continues on page 19

Student Number

Question 26 (continued)

(c) Predict the effect on the polyester's rigidity and melting point as the polymer chains increase in length. Explain your predictions. **3**

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(d) The structure of addition polymers can be modelled using Molymods. Outline an advantage and disadvantage of using models in science. **2**

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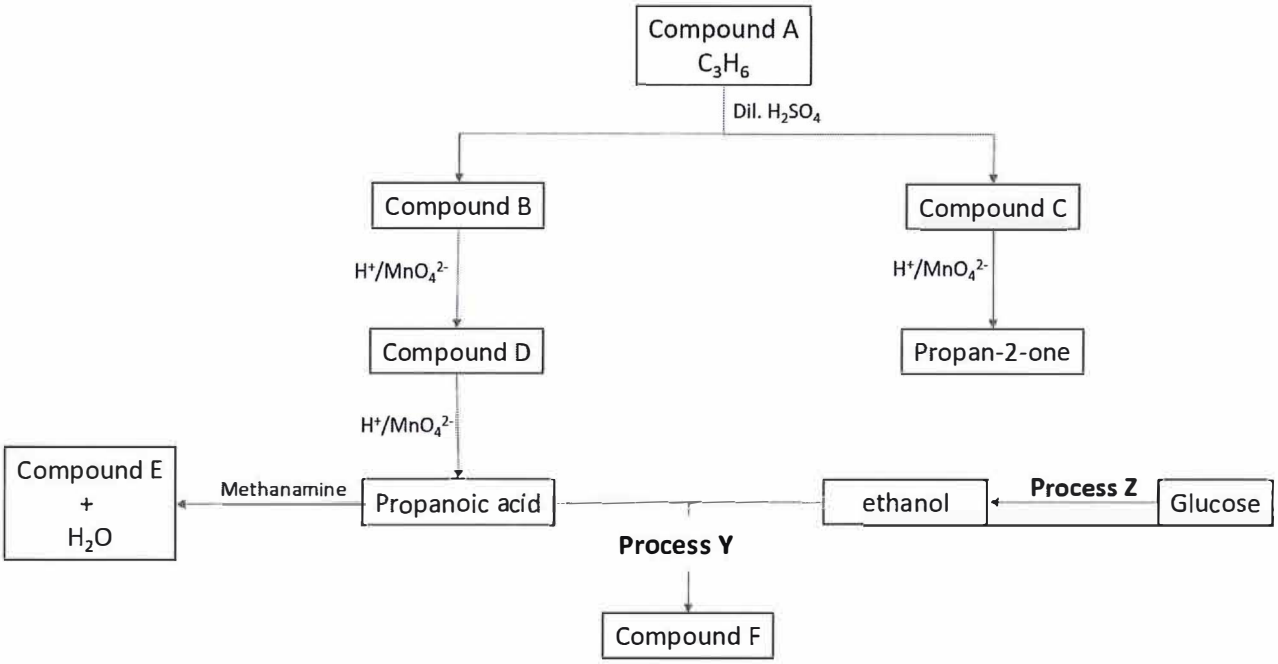
End of Question 26

Question 27 (11 marks)

The flowchart below illustrates the processes involved in the synthesis of some organic compounds.



(a) Using IUPAC nomenclature, identify each of the compounds listed in the flow chart. **6**

Compound	*IUPAC name*
A	
B	
C	
D	
E	
F	

Question 27 continues on page 21

Student Number

Question 27 (continued)

(b) Draw full structural formula for Compounds E and F. **2**

Compound E	*Compound F*

(c) Identify processes Y and Z. Give TWO experimental conditions that are required for each of these processes to occur. **3**

Process	*Experimental Conditions*
Y ……	
Z ……	

End of Question 27

Question 28 (4 marks)

Compare the uses, structure and properties of soap and anionic synthetic detergents. Include a diagram in your answer. **4**

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Student Number

Question 29 (7 marks)

Hex-1-ene gas burns in oxygen to produce carbon dioxide and water vapour.

$$C_6H_{12\,(g)} + 9O_{2\,(g)} \rightarrow 6CO_{2\,(g)} + 6H_2O_{\,(g)}$$

(a) The change in enthalpy for this reaction is -3773 kJ/mol (25 °C, 100 kPa). State if this change in enthalpy favours a spontaneous reaction and justify your answer. **2**

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(b) The change in entropy for this reaction is 188 J/mol (25 °C, 100 kPa). State if this change in entropy favours a spontaneous reaction and justify your answer. **2**

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(c) Determine if this reaction is spontaneous at 25 °C. Use a calculation to support your answer. **3**

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Question 30 (4 marks)

Most plants contain pH-sensitive pigments, making some of them ideal for use as a natural indicator. During the course of your study you have prepared and tested a natural indicator.

(a) Outline the method you used to prepare a natural indicator. **2**

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(b) Explain why the natural indicator solution you prepared can be used to qualitatively determine the acidity or basicity a solution. In your response, include a suitable chemical equation. **2**

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Student Number

Question 31 (5 marks)

Hydrogen sulfide, in solution, is a diprotic acid and ionises in two stages.

$$H_2S(aq) + H_2O(l) \rightleftharpoons HS^-(aq) + H_3O^+(aq) \quad K_{a1} = 9.6 \times 10^{-8}\ M$$

$$HS^-(aq) + H_2O(l) \rightleftharpoons S^{2-}(aq) + H_3O^+(aq) \quad K_{a2} = 1.3 \times 10^{-14}\ M$$

A student made two assumptions when estimating the pH of a 0.010 M solution of H_2S:

1. The pH can be estimated by considering only the first ionisation reaction.
2. The concentration of H_2S at equilibrium is approximately equal to 0.010 M.

(a) Explain why these two assumptions are justified. **2**

Assumption 1:.....

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Assumption 2:.....

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(b) Use the TWO assumptions given above to calculate the pH of a 0.010 M solution of H_2S. **3**

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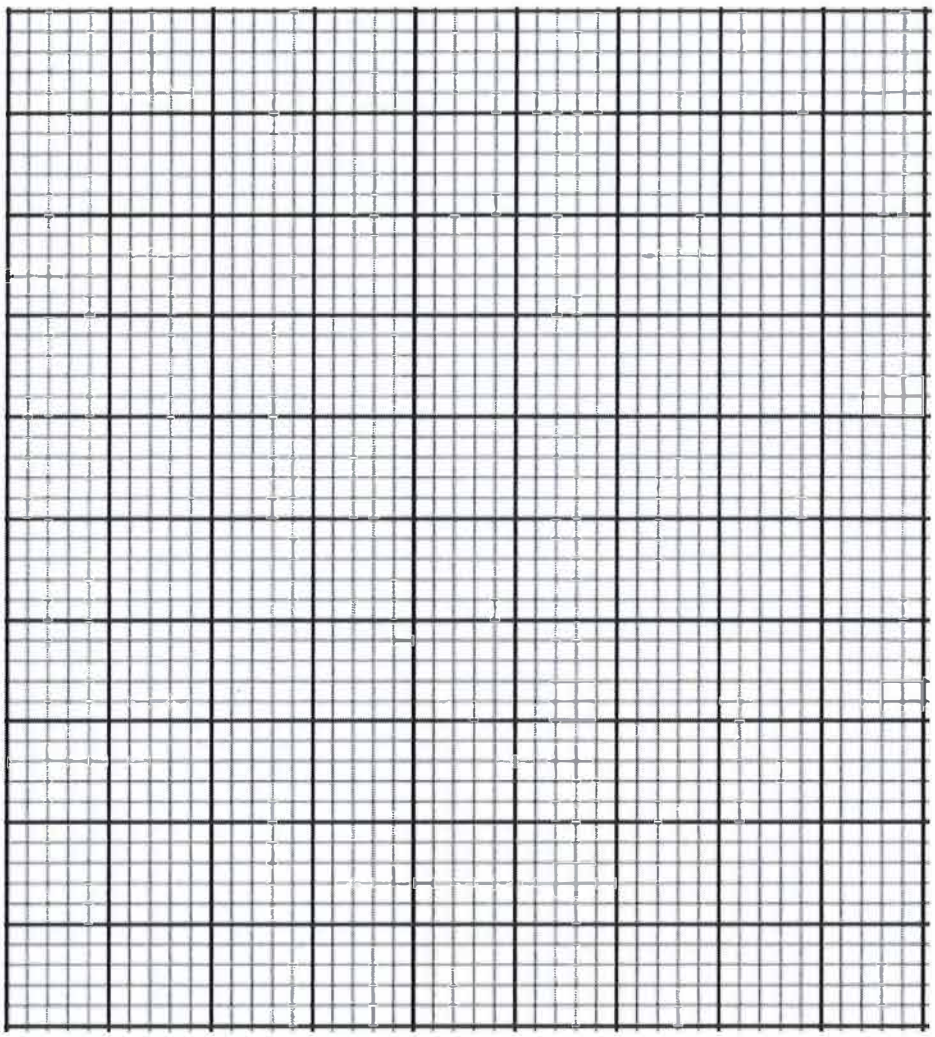
Question 32 (6 marks)

The boiling points of similar molar mass straight chain alkanes, primary amines and straight chain carboxylic acids listed in the table below.

Alkane		*Amine*		*Carboxylic acid*	
Molar Mass (g/mol)	*Boiling Point (°C)*	*Molar Mass (g/mol)*	*Boiling Point (°C)*	*Molar Mass (g/mol)*	*Boiling Point (°C)*
58	-1	59	49	61	118
72	36	73	78	74	141
86	69	87	104	88	164
100	98	102	132	102	186
114	126	115	155	116	205

(a) On the grid below, plot the boiling point data for each homologous series. Construct a line of best fit for each data sets. **3**



Question 32 continues on page 27

Student Number

Question 32 (continued)

(b) Identify and explain any trends evident in the graph for all three homologous series. **3**

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End of Question 32

Question 33 (4 marks)

A solution is made by mixing 500.0 mL of 0.12 M NaOH solution with 500.0 mL of 0.10 M $Mg(NO_3)_2$.

(a) Write a balanced chemical equation for this reaction. **1**

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(b) Determine if a precipitate will form as a result of mixing these solutions. Support your answer with relevant chemical equations. **3**

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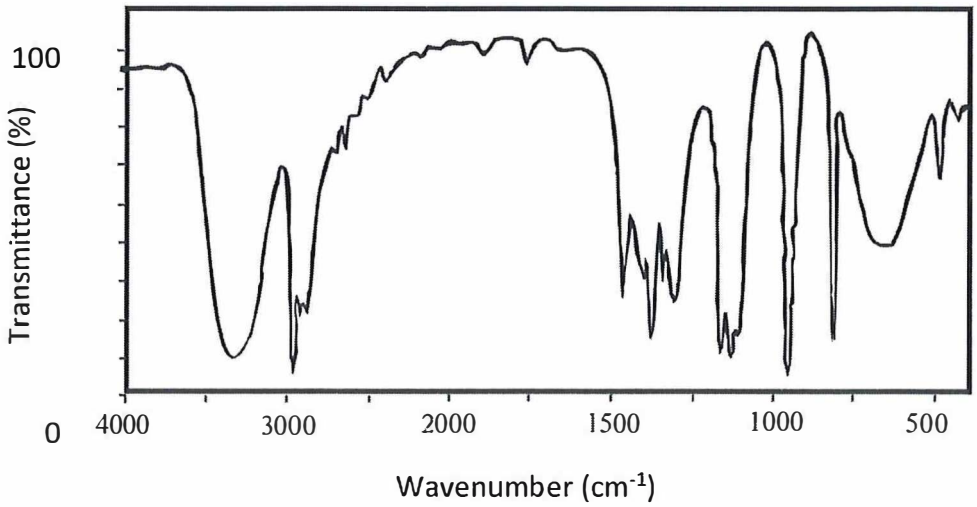
Student Number

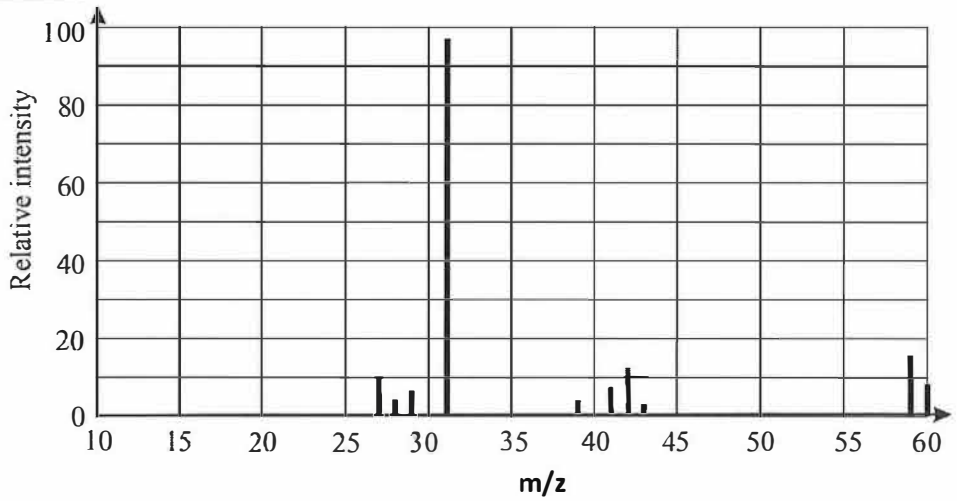
Question 34 (6 marks)

Both spectra shown below are of the same unknown organic compound.

IR spectrum



Mass Spectrum



(a) What functional group is indicated by the absorption band between 3200 and 3500 cm^{-1}? **1**

.....

(b) From the IR spectrum, how can we be sure the organic compound is not a ketone or aldehyde? **1**

.....

(c) Identify the relative molecular mass of the unknown compound. **1**

.....

Question 34 continues on page 30

Question 34 (continued)

(d) On the basis of the functional group identified from the IR spectrum and the relative molecular mass of the compound, identify the unknown compound. Explain your reasoning. **3**

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End of Paper

Student Number

Barker College

2020 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

PM WEDNESDAY 12th AUGUST

85 copies

Section I - Multiple Choice
Choose the best response and fill in the response oval completely

Start Here →

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

1. A system which has both mass and energy transfer across the boundary is called a(n):

   A. Closed System

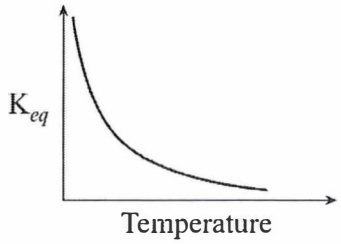
   B. Open System

   C. Isolated System

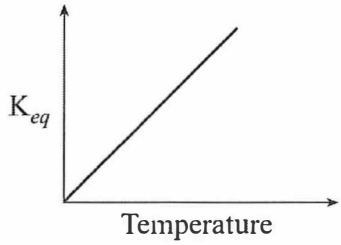
   D. None of the above

2. The relationship between Keq and temperature for an exothermic reaction is represented by

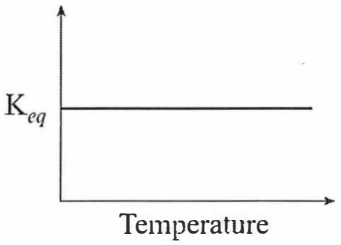
   A.



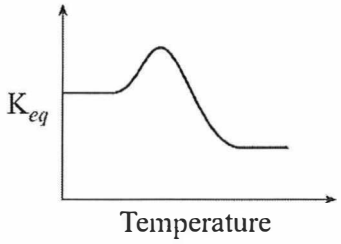
   B.



   C.



   D.



3. The solubility of $Mn(IO_3)_2$ is 4.8×10^{-3} M. What is the value of Ksp ?

   A. 1.1×10^{-7}

   B. 4.4×10^{-7}

   C. 7.1×10^{-6}

   D. 1.1×10^{-1}

4. When comparing 1.0 M solutions of bases, the base with the lowest $[OH^-]$ is the:

   A. weakest base and it has the largest K_b value.

   B. strongest base and it has the largest K_b value.

   C. weakest base and it has the smallest K_b value.

   D. strongest base and it has the smallest K_b value.

5. Consider the following solubility data.

Compound	*Solubility constant at 25°C*
$CuSO_4$	2.28×10^{-2}
$BaSO_4$	1.08×10^{-10}
$CaSO_4$	4.93×10^{-5}

The order of cation concentration, from highest to lowest, is:

A. $[Ba^{2+}] > [Ca^{2+}] > [Cu^{2+}]$

B. $[Ca^{2+}] > [Cu^{2+}] > [Ba^{2+}]$

C. $[Cu^{2+}] > [Ca^{2+}] > [Ba^{2+}]$

D. $[Cu^{2+}] > [Ba^{2+}] > [Ca^{2+}]$

6. What is the advantage of a biofuel compared to a fuel derived from fossil fuels?

A. No energy is used to extract and isolate a biofuel from its source.

B. The amount of energy per mole is greater for the biofuel compound.

C. Only the biofuel is produced naturally in an endothermic reaction.

D. The biofuel can be replenished quickly using natural processes

7. A sample of compound M is analysed in a mass spectrometer where it forms the molecular ion M^+ according to:

$$M + e^- \rightarrow M^+ + 2e^-$$

Some of the molecular ions fragment as follows.

$$M^+ \rightarrow X^+ + Y \text{ and}$$

$$M^+ \rightarrow X + Y^+$$

The mass spectrum would show peaks due to the species

A. M^+, X, X^+, Y and Y^+ only.

B. M^+, X^+ and Y^+ only.

C. X^+ and Y^+ only.

D. X and Y only.

8. Pure water self-ionises as shown by the equation:

$$2H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$

The following table shows the value of the ionisation constant (Kw) of pure water at various temperatures and at a constant pressure

Temperature (°C)	0	25	50	75	100
K_w	1.1×10^{-15}	1.0×10^{-14}	5.5×10^{-14}	2.0×10^{-13}	5.6×10^{-13}

Given this data, which one of the following statements about pure water is correct?

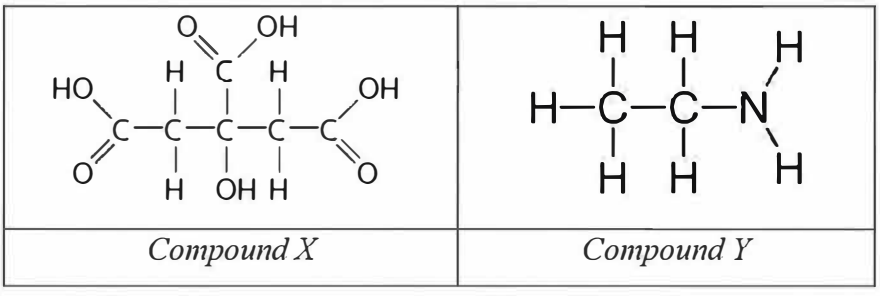
A. The $[OH^-]$ will decrease with increasing temperature.

B. The $[H_3O^+]$ will increase with increasing temperature.

C. Its pH will increase with increasing temperature.

D. Its pH will always be exactly 7 at any temperature.

9. Consider the following two compounds.



Compound X | *Compound Y*

Which of the following best describes the properties of compounds X and Y?

A. Both compounds are acidic.

B. Both compounds are basic.

C. Compound X is basic and compound Y is acidic.

D. Compound X is acidic and compound Y is basic.

Use the following information to answer Questions 10 and 11.

Hydrogen is produced on an industrial scale from methane. The equation for the reaction is

$$2H_2O_{(g)} + CH_{4(g)} \rightleftharpoons CO_{2(g)} + 4H_{2(g)}$$

10. The expression for the equilibrium constant for the reverse reaction is:

A. $K = \dfrac{[H_2O]^2\,[CH_4]}{[H_2]^4\,[CO_2]}$

B. $K = \dfrac{[H_2]^4\,[CO_2]}{[H_2O]^2\,[CH_4]}$

C. $K = \dfrac{[H_2O]\,[CH_4]}{[H_2]\,[CO_2]}$

D. $K = \dfrac{4[H_2]\,[CO_2]}{2[H_2O]\,[CH_4]}$

11. If the temperature remains constant and the volume of the equilibrium system is halved, the immediate concentration of hydrogen will:

A. increase.

B. decrease.

C. not change.

D. decrease then increase.

12. Infrared spectroscopy detects frequencies of infrared light that are absorbed by a molecule. These absorptions are based on

A. movement of electrons between molecular energy levels.

B. movement of electrons between different atomic energy levels.

C. bending or stretching of covalent bonds in molecules.

D. absorption of radiation by nuclei placed in a magnetic field.

13. Carbon tetrachloride, CCl_4 is often used as a solvent in chemistry labs. Which statement is ***false*** about CCl_4?

A. It is a non-polar molecule.

B. Its main intermolecular forces are dispersion forces.

C. It has a tetrahedral shape.

D. It is the product of an addition reaction between methane and chlorine in the presence of UV light.

14. Which of the indicators listed in the table below would be ***most*** suitable for use during the titration of ammonia with hydrochloric acid?

Indicator	*pH*									
	0-4		*5-6*	*7*	*8-10*		*11-14*			
Litmus	red		red	purple	blue		blue			
Methyl Orange	red	orange	yellow	yellow	yellow		yellow			
Phenolphthalein	colourless		colourless	colourless	pink	red	red			

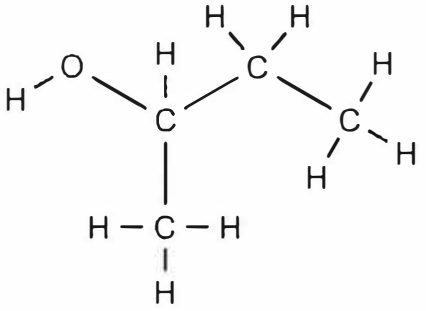
A. Methyl orange

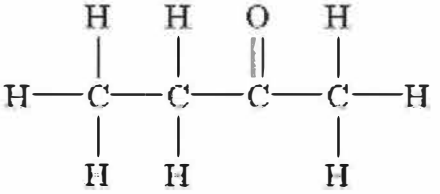
B. Litmus

C. Phenolphthalein

D. All three indicators would be equally suitable.

15. What is the correct relationship between the two molecules shown below?





A. They are functional group isomers

B. They are positional isomers

C. They are chain isomers

D. There is no relationship

16. Which combination could you use to prepare a buffer solution?

A. CH_3COONa and $HCOONa$

B. $NaNO_3$ and HNO_3

C. Na_2SO_4 and H_2SO_4

D. CH_3COONa and CH_3COOH

17. Which one of the following statements about 10.0 mL of 0.10 M HCl and 10.0 mL of 0.10 M CH_3COOH solutions is true?

A. Each solution will have the same electrical conductivity.

B. Each solution will react completely with 10.0 mL of 0.10 M NaOH solution.

C. Each solution will react at the same rate with 1.00 g of magnesium ribbon.

D. The concentration of H_3O^+ ions will be greater in the CH_3COOH solution.

18. A student performed an experiment in which 100 mL of water was heated by burning methanol in a spirit burner. What is the maximum change in temperature of the water when 0.500 g of methanol is completely combusted? (Assume all heat from the flame is absorbed into the water). The enthalpy of combustion of methanol is -726 kJ/mol.

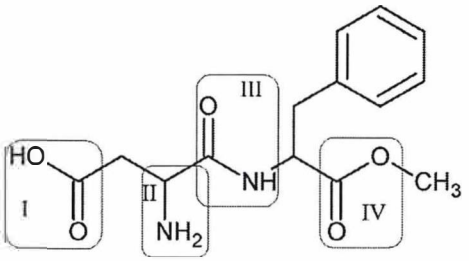
A. 0.027 °C

B. 1.74 °C

C. 27.1 °C

D. 36.3 °C

19. Aspartame is an artificial sweetener 200 times sweeter than sucrose. It is commonly used as a sugar substitute in foods and beverages. Its chemical structure is shown below.



The names of the functional groups labelled I, II, III and IV are:

	I	*II*	*III*	*IV*
A	Hydroxyl	Amine	Amide	Carbonyl
B	Carboxyl	Amine	Amide	Ester
C	Carboxyl	Carbonyl	Ammonia	Ester
D	Carboxyl	Amide	Amine	Carbonyl

20. How would the concentration of $Pb^{2+}_{(aq)}$ ions in equilibrium with $PbI_{2(s)}$ be affected if the concentration of $I^-_{(aq)}$ ions were doubled?

A. no change

B. increased by a factor of 2

C. decreased by a factor of 2

D. decreased by a factor of 4

End of Section I

Question 21 (4 marks)

A student takes a 50.0 mL sample from a saturated solution of silver chloride which was kept at 25°C.

(a) Write an equilibrium equation for solid silver chloride and its ions in solution. **1**

$AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$

(b) Calculate the mass of silver ions in the 50.0 mL sample. **3**

$K_{sp} = [Ag^+][Cl^-] = 1.77 \times 10^{-10}$

$x \cdot x = 1.77 \times 10^{-10}$

$x^2 = 1.77 \times 10^{-10}$

$x = \sqrt{1.77 \times 10^{-10}}$

$x = 1.330 \times 10^{-5}$ mol/L

$n = C \times V = 1.330 \times 10^{-5} \times .05 = 6.652 \times 10^{-7}$ mol

$m = n \times MM = 6.652 \times 10^{-7} \times 107.9 = 7.17758 \times 10^{-5}$ g

7.18×10^{-5} g (3 s.f.)

Question 22 (3 marks)

Sodium hydrogen carbonate ($NaHCO_3$) is an amphiprotic compound.

(a) Write TWO net ionic equations showing its amphiprotic behaviour. **2**

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

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

(b) Identify ONE conjugate acid-base pair from your equations. **1**

HCO_3^- / H_2CO_3 HCO_3^- / CO_3^{2-} H_3O^+ / H_2O OH^- / H_2O

Student Number

Question 23 (4 marks)

Hydrofluoric acid is a weak acid. The pH of a 0.025 M solution of hydrofluoric acid is 2.39.

(a) Calculate the Ka of the hydrofluoric acid. **2**

$HF \rightleftharpoons H^+ + F^-$ $K_a = \frac{[H^+][F^-]}{[HF]}$

$[H^+] = 10^{-2.39} = 4.07 \times 10^{-3}$

R	$1\,HF$	$1\,H^+$	$1\,F^-$
1	0.025	0	0
(	-4.07×10^{-3}	$+4.07\times10^{-3}$	$+4.07\times10^{-3}$
E	.02093	4.07×10^{-3}	4.07×10^{-3}

$K_a = \frac{(4.07\times10^{-3})^2}{.02093}$

$= 7.93\times10^{-4}$

(b) Calculate the pKa of the hydrofluoric acid. **1**

$pK_a = -\log_{10}(K_a)$

$= -\log_{10}(7.93\times10^{-4})$

$= 3.101$

(c) Calculate the percentage dissociation of the hydrofluoric acid. **1**

$\%\ \text{dissociation} = \frac{[H^+]}{[HF]} \times \frac{100}{1}$

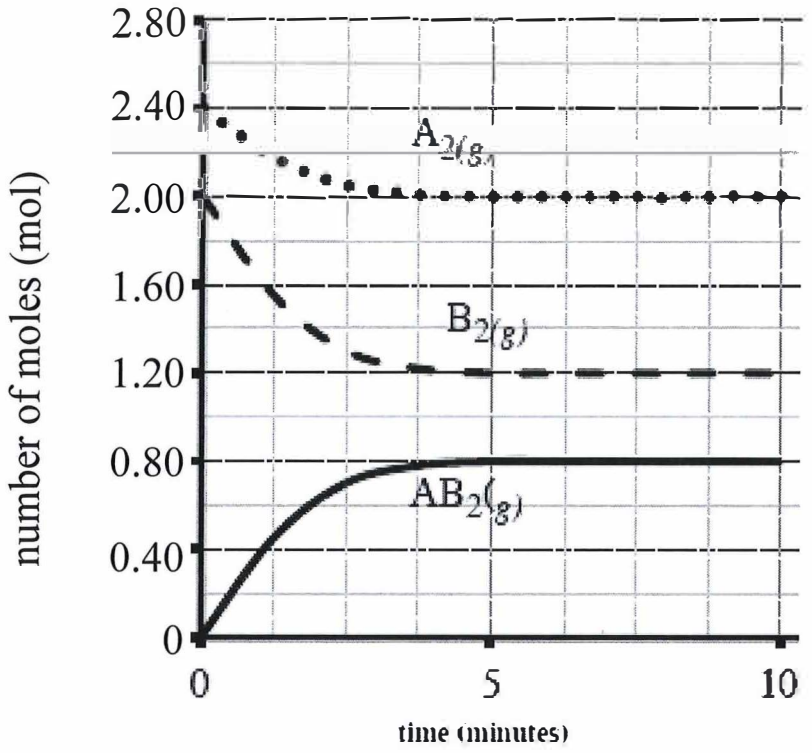
$= \frac{4.07}{0.025} \times \frac{100}{1} = 16.3\%$

Question 24 (7 marks)

(a) Consider the following reaction that is taking place in a 2.00 L closed reaction flask at 25°C:

$$A_{2\,(g)} + 2B_{2\,(g)} \rightleftharpoons 2AB_{2\,(g)}$$

The following graph represents the changes in the number of moles of each gas in the flask over the first 10 minutes



(i) Using data from the graph, determine the value of the equilibrium constant (Keq) for the reaction. **3**

$K_{eq} = \frac{[AB]^2}{[A_2][B_2]^2} = \frac{\left(\frac{0.80}{2}\right)^2}{\left(\frac{2.00}{2}\right)\left(\frac{1.20}{2}\right)^2}$

$= .444$ (3 s.f.)

Question 24 continues on page 15

Student Number

Question 24 (continued)

(ii) At a time of 15 minutes, some $B_{2\,(g)}$ was removed from the system. At 20 minutes, the contents of the reaction flask were analysed and the following data were obtained.

$$[A_2] = 1.05 \text{ mol L}^{-1}$$
$$[B_2] = 0.40 \text{ mol L}^{-1}$$
$$[AB_2] = 0.30 \text{ mol L}^{-1}$$

Determine if the system has reached equilibrium at 20 minutes and describe the rates of the forward and reverse reactions at this time?

2

$Q = \frac{[AB]^2}{[A_2][B_2]^2} = \frac{.3^2}{1.05 \times .4^2} = 0.5357$

$Q > K_{eq}$ therefore not at equilibrium

Equilibrium will shift left/backwards

Rate of reverse reaction will be greater than rate of forward reaction

(b) Consider the equilibrium system involving the oxidation of nitric oxide

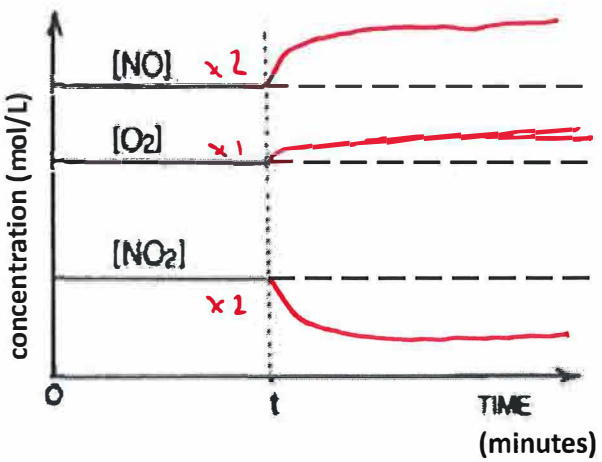
$$2NO_{(g)} + O_{2\,(g)} \rightleftharpoons 2NO_{2\,(g)} \qquad \Delta H = -556\text{kJ}$$

If the temperature was increased at time t, determine the effect on the position of equilibrium and complete the graph to show how the change will affect the concentration of reactants and product. **2**

(i) Effect on equilibrium position:

shift left/ backwards

(ii)



Question 25 (7 marks)

A pharmaceutical manufacturer claims that their pain-relieving tablets contain 100% aspirin. To determine the actual percentage by mass of aspirin in an aspirin tablet, the following procedure, involving a back titration, was used.

Step 1: Three aspirin tablets, each with a mass of 300.0 mg, were crushed and dissolved in excess sodium hydroxide solution. Exactly 100.0 mL of 0.204 mol L^{-1} solution of sodium hydroxide was used. The mixture was boiled to ensure complete reaction.

Step 2: The excess sodium hydroxide solution was titrated with hydrochloric acid as follows: 20.0 mL of the solution from step 1 was pipetted into a conical flask and 0.125 mol L^{-1} hydrochloric acid was placed in the burette. The indicator, phenolphthalein, was used and an average titre of 17.89 mL of hydrochloric acid was required to reach the end-point.

(a) Calculate the number of moles of sodium hydroxide added in step 1. **1**

$n = C \times V = .204 \text{ mol/L} \times 0.1 \text{ L}$

$= .0204 \text{ mol of NaOH}$

(b) Calculate how many moles of sodium hydroxide reacted with the aspirin. **3**

$NaOH + HCl \longrightarrow NaCl + H_2O$

$n(HCl) = C \times V = .125 \times .01789 = 2.224 \times 10^{-3} \text{ mol HCl}$

1:1 ratio of NaOH to HCl

So moles of NaOH in 20mL is 2.224×10^{-3} mol

moles of NaOH in 100mL is $5 \times 2.224 \times 10^{-3}$

$= .01118125$

Amount reacted = initial − excess $= 0.0204 - 0.01118125$

$= 0.009287 \text{ mol}$ or 9.22×10^{-3} mol (3 s.f.)

Question 25 continues on page 17

Student Number

Question 25 (continued)

(c) Each aspirin molecule requires two hydroxide ions for complete reaction. Calculate the percentage by mass of aspirin in one aspirin tablet. (The molar mass of aspirin is 180.154 g mol^{-1}.) **3**

$n(\text{aspirin}) = \frac{n(OH^-)}{2} = 4.61 \times 10^{-3}$ mol

$m(\text{aspirin}) = n \times MM = 4.61 \times 10^{-3} \times 180.154$

$= .830$ g in 3 tablets

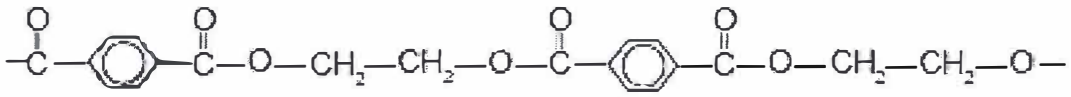
In 1 tablet there is $\frac{.830}{3} = .2768$ g $= 276.8$ mg

% mass $= \frac{276.8}{300} \times \frac{100}{1} = 92.3\%$

End of Question 25

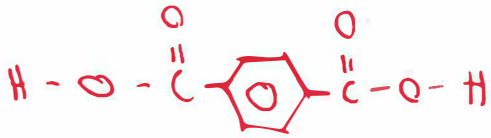
Question 26 (8 marks)

Dacron is the trade name for a common polyester used in making clothes and water bottles. Part of its structural formula is given below:

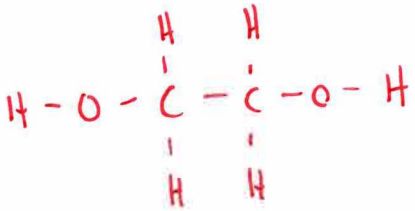


(a) Draw the structural formula for the two monomers that react to form this polymer. **2**

Monomer one:



Monomer two:



(b) Name the other product of this polymerisation reaction. **1**

water

Question 26 continues on page 19

Student Number

Question 26 (continued)

(c) Predict the effect on the polyester's rigidity and melting point as the polymer chains increase in length. Explain your predictions. **3**

Polymer chains contain ester linkages which are polar. This creates dipole-dipole forces (and dispersion forces) which exist between chains. These forces accumulate as chain length increases, therefore melting point also increases as the polymer increases in length. Rigidity increases due to the greater number of large phenyl rings along the chain which increases chain stiffening

(d) The structure of addition polymers can be modelled using Molymods. Outline an advantage and disadvantage of using models in science. **2**

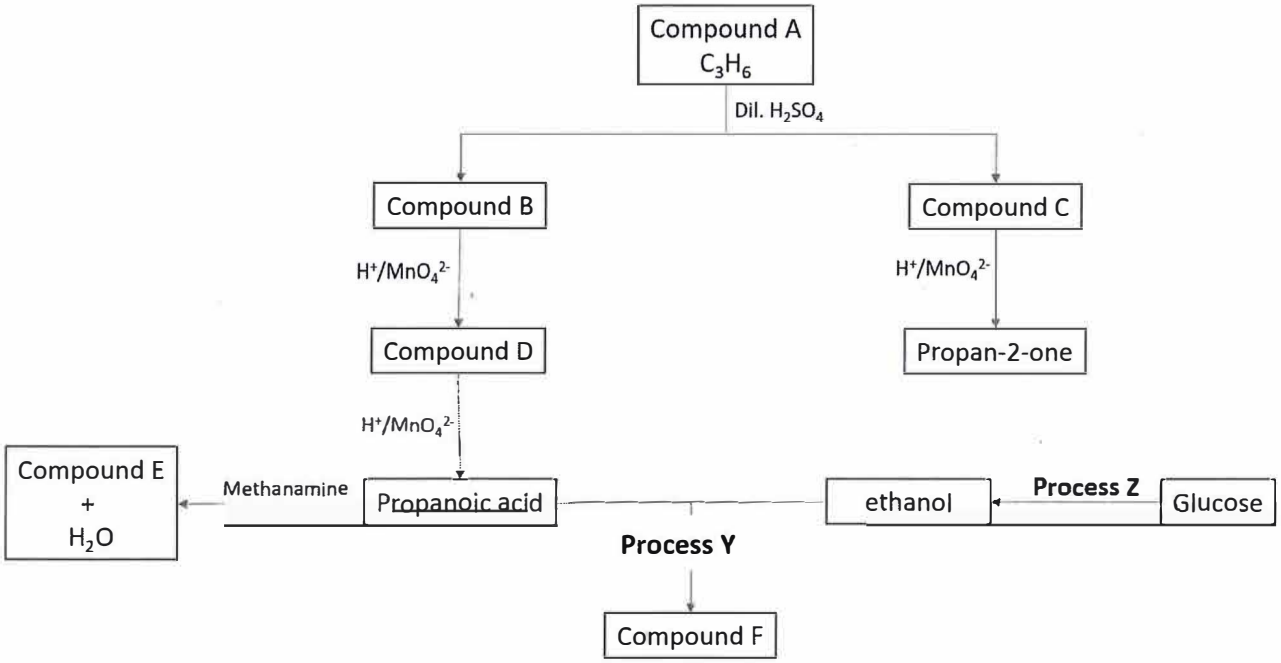
Advantages: • Easy to visualise the making and breaking of bonds
• see spatial arrangement of atoms in molecule
• visualise reaction

Disadvantages • No information about rate of reaction
• Can't visualise the movement of electrons
• No information regarding intermolecular forces
• Overly simplified view of a molecule

End of Question 26

Question 27 (11 marks)

The flowchart below illustrates the processes involved in the synthesis of some organic compounds.



(a) Using IUPAC nomenclature, identify each of the compounds listed in the flow chart. **6**

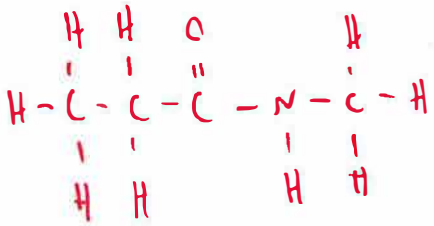
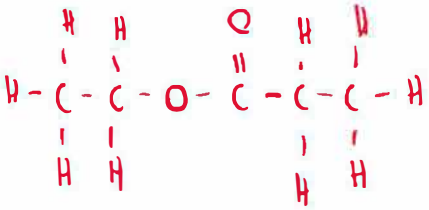
Compound	*IUPAC name*
A	propene
B	propan-1-ol
C	propan-2-ol
D	propanal
E	N-methylpropanamide
F	ethyl propanoate

Question 27 continues on page 21

Student Number

Question 27 (continued)

(b) Draw full structural formula for Compounds E and F. **2**

Compound E	*Compound F*
	

(c) Identify processes Y and Z. Give TWO experimental conditions that are required for each of these processes to occur. **3**

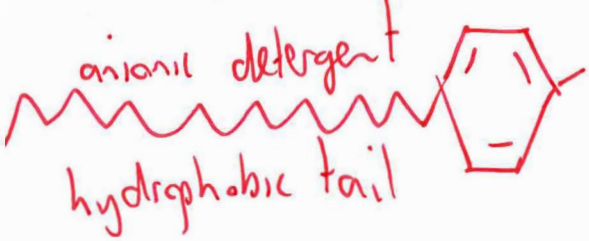
Process	*Experimental Conditions*
Y esterification	reflux high heat
	conc H_2SO_4
Z fermentation	anaerobic yeast
	37° C

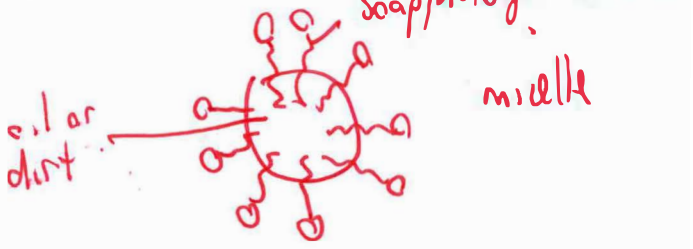
End of Question 27

Question 28 (4 marks)

Compare the uses, structure and properties of soap and anionic synthetic detergents. Include a diagram in your answer. **4**

Both soaps & detergents have a similar structure consisting of a long non-polar, hydrophobic carbon chain (tail) and a charged, hydrophillic head.
This structure enables the hydrophobic tail to form dispersion forces with non-polar substances like oil or grease, while the charged head groups form ion-dipole & hydrogen bonding with water creating a micelle.
Soaps can only function effectively in soft water, whereas anionic detergents can function in hard water as they do not form a precipitate with calcium or magnesium ions. Detergents can also work in acidic water as they do not become protonated.
Soaps are useful for personal hygiene products as they do not remove the natural body oils from the skin. Detergents are more potent and can not be used to clean the skin but instead have uses such as laundry detergents and dishwashing liquids.





Student Number

Question 29 (7 marks)

Hex-1-ene gas burns in oxygen to produce carbon dioxide and water vapour.

$$C_6H_{12\,(g)} + 9O_{2\,(g)} \rightarrow 6CO_{2\,(g)} + 6H_2O_{\,(g)}$$

(a) The change in enthalpy for this reaction is -3773 kJ/mol (25 °C, 100 kPa). State if this change in enthalpy favours a spontaneous reaction and justify your answer. **2**

The enthalpy change is negative therefore the reaction is exothermic

Exothermic reactions are energetically favourable which favours spontaneity

(b) The change in entropy for this reaction is 188 J/mol (25 °C, 100 kPa). State if this change in entropy favours a spontaneous reaction and justify your answer. **2**

The entropy change is positive therefore disorder/chaos is increasing.

Positive entropy favours spontaneity

(c) Determine if this reaction is spontaneous at 25 °C. Use a calculation to support your answer. **3**

$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$ $\Delta S^\circ = .188$ kJ/mol

$\Delta H^\circ = -3773$ kJ/mol

$\Delta G^\circ = -3773 - (298.15 \times .188)$

$= -3829.1$

As ΔG° is negative this reaction will be spontaneous.

Question 30 (4 marks)

Most plants contain pH-sensitive pigments, making some of them ideal for use as a natural indicator. During the course of your study you have prepared and tested a natural indicator.

(a) Outline the method you used to prepare a natural indicator. **2**

- 3 leaves of red cabbage were cut into approximately $1cm^2$ pieces
- The cabbage pieces were boiled in enough water to cover the pieces for approximately 20 minutes.
- The solution was then strained to remove the cabbage pieces, leaving only the natural indicator solution

(b) Explain why the natural indicator solution you prepared can be used to qualitatively determine the acidity or basicity a solution. In your response, include a suitable chemical equation. **2**

The natural indicator is able to change a different colour in acidic or basic solutions. Used in conjunction with some known reference samples of an acid and base (such as vinegar and cloudy ammonia respectively) the indicator can then be used to provide a qualitative colour change to indicate the acidity or alkalinity of a substance.

Natural indicators are often weak acids which work via the following equation:

$$HIn \rightleftharpoons H^+ + In^-$$

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Question 31 (5 marks)

Hydrogen sulfide, in solution, is a diprotic acid and ionises in two stages.

$$H_2S(aq) + H_2O(l) \rightleftharpoons HS^-(aq) + H_3O^+(aq) \quad K_{a1} = 9.6 \times 10^{-8}\ M$$

$$HS^-(aq) + H_2O(l) \rightleftharpoons S^{2-}(aq) + H_3O^+(aq) \quad K_{a2} = 1.3 \times 10^{-14}\ M$$

A student made two assumptions when estimating the pH of a 0.010 M solution of H_2S:

1. The pH can be estimated by considering only the first ionisation reaction.
2. The concentration of H_2S at equilibrium is approximately equal to 0.010 M.

(a) Explain why these two assumptions are justified. **2**

Assumption 1: The K_{a2} value is so small, there are negligible products formed for this second reaction. This means $[HS^-]$ is virtually identical for both reactions as it $[H_3O^+]$

Assumption 2: K_{a1} is sufficiently small that the equilibrium concentration of $H_2S(aq)$ is very similar to the initial concentration of $H_2S(aq)$

(b) Use the TWO assumptions given above to calculate the pH of a 0.010 M solution of H_2S. **3**

$$K_{a1} = \frac{[HS^-][H_3O^+]}{[H_2S]} = 9.6 \times 10^{-8}\ M$$

$$K_{a1} = \frac{x \cdot x}{.010} = 9.6 \times 10^{-8}$$

$$x^2 = 9.6 \times 10^{-8} \times .010$$

$$x = \sqrt{9.6 \times 10^{-10}} = 3.098 \times 10^{-5}$$

$$pH = -\log(3.098 \times 10^{-5})$$

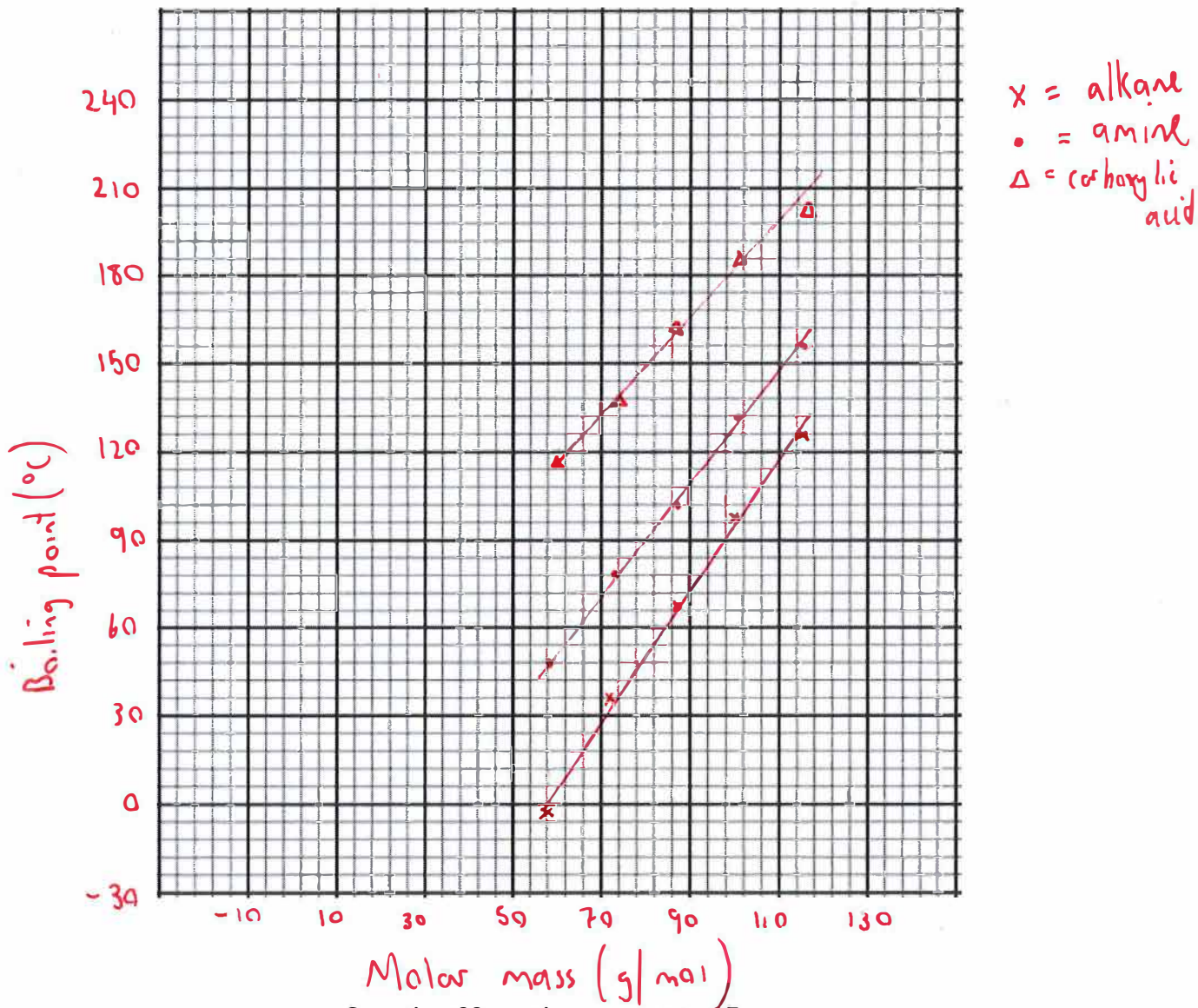
$$= 4.51 \text{ (2 d.p.)}$$

Question 32 (6 marks)

The boiling points of similar molar mass straight chain alkanes, primary amines and straight chain carboxylic acids listed in the table below.

Alkane		*Amine*		*Carboxylic acid*	
Molar Mass (g/mol)	*Boiling Point (°C)*	*Molar Mass (g/mol)*	*Boiling Point (°C)*	*Molar Mass (g/mol)*	*Boiling Point (°C)*
58	-1	59	49	61	118
72	36	73	78	74	141
86	69	87	104	88	164
100	98	102	132	102	186
114	126	115	155	116	205

(a) On the grid below, plot the boiling point data for each homologous series. Construct a line of best fit for each data sets. **3**



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Question 32 (continued)

(b) Identify and explain any trends evident in the graph for all three homologous series. **3**

for all three homologous series as molar mass increases, boiling point increases. This is due to the increase in dispersion forces as the length of the carbon chain increases.

Alkanes have the lowest boiling points relative to molar mass as they are non-polar molecules and only have dispersion forces as their intermolecular forces.

Amines have the next highest boiling points relative to molar mass as due to the N-H amine group. These molecules have hydrogen bonds as the intermolecular forces between molecules. Hydrogen bonds are stronger than dispersion forces and therefore require a greater amount of heat energy to break.

Carboxylic acids have the highest relative boiling points as there is a greater amount of poss. ble H-bonding due to the presence of both an O-H and a C=O. Carboxylic acids are able to form dimer structures with hydrogen bonds.

End of Question 32

The convergence of boiling points as molar mass increases between the three homologous series is explained by the functional group having less effect on the intermolecular forces as carbon chain length increases, with dispersion forces becoming the dominant intermolecular force for all three homologous series.

Question 33 (4 marks)

A solution is made by mixing 500.0 mL of 0.12 M NaOH solution with 500.0 mL of 0.10 M $Mg(NO_3)_2$.

(a) Write a balanced chemical equation for this reaction. **1**

$2NaOH_{(aq)} + Mg(NO_3)_{2(aq)} \longrightarrow 2NaNO_{3(aq)} + Mg(OH)_{2(s)}$

(b) Determine if a precipitate will form as a result of mixing these solutions. Support your answer with relevant chemical equations. **3**

$n(Mg^{2+}) = n(Mg(NO_3)_2) = C \times V = .1 \times .5 = .05\ mol\ Mg^{2+}$

$c(Mg^{2+}) = \frac{n}{V} = \frac{.05}{1} = .05\ M$

$n(OH^-) = n(NaOH) = C \times V = .12 \times .5 = .06\ mol\ OH^-$

$c(OH^-) = \frac{n}{V} = \frac{.06}{1} = .06\ M$

$Q_{sp} = [Mg^{2+}][OH^-]^2$

$Q_{sp} = 0.05 \times 0.06^2$

$= 1.8 \times 10^{-4}$

$K_{sp} = 5.61 \times 10^{-12}$

$Q_{sp} > K_{sp}$ therefore precipitate will form

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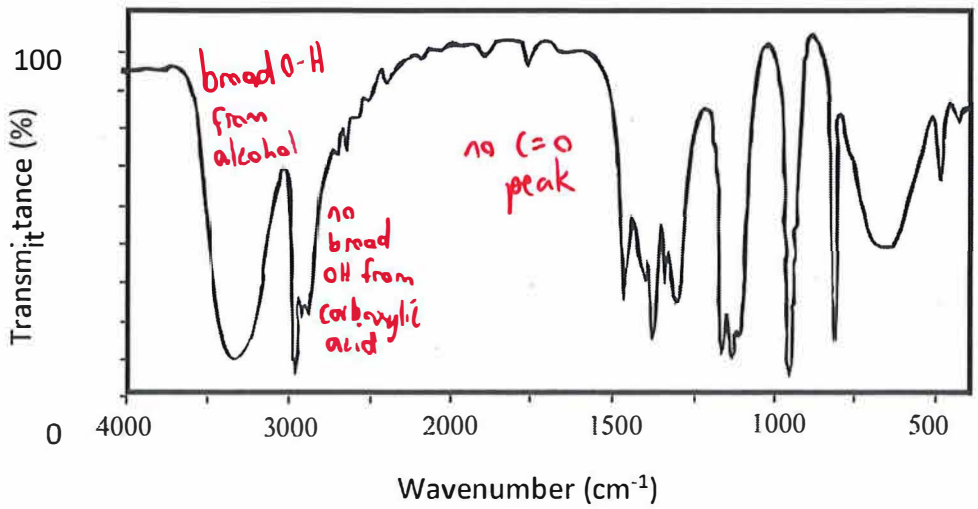
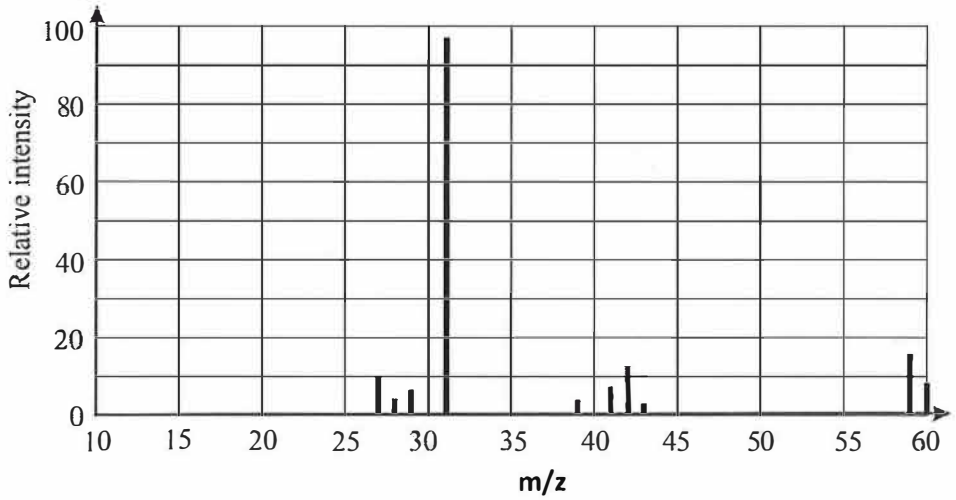
Question 34 (6 marks)

Both spectra shown below are of the same unknown organic compound.

IR spectrum



Mass Spectrum



(a) What functional group is indicated by the absorption band between 3200 and 3500 cm^{-1}? **1**

hydroxyl (O-H) functional group associated with alcohol

(b) From the IR spectrum, how can we be sure the organic compound is not a ketone or aldehyde? **1**

no C=O peak around 1680 - 1750

(c) Identify the relative molecular mass of the unknown compound. **1**

parent molecule is 60 m/z so 60 g/mol

Question 34 continues on page 30

Question 34 (continued)

(d) On the basis of the functional group identified from the IR spectrum and the relative molecular mass of the compound, identify the unknown compound. Explain your reasoning. **3**

The O-H peak is in the region for alcohol (3230 - 3550) and not for acids (2500 - 3000). This means the compound must be an alcohol. The molar mass indicated it is propanol.

The mass spectrum indicates the compound is propan-1-ol as it has a peak at 31 m/z for the $-\overset{H}{\underset{H}{C}}-O-H$ fragment and does not have a peak at 30 for a fragment expected from propan-2-ol of $-\overset{H}{\underset{O-H}{\overset{|}{\underset{|}{C}}}}-H$.

End of Paper