CSSA

# 2022
## TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

**DO NOT REMOVE PAPER FROM EXAMINATION ROOM**

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Centre Number

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Student Number

# Chemistry

Afternoon Session
Friday, 5 August 2022

**General Instructions**

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- NESA-approved calculators may be used
- Use the Multiple-Choice Answer Sheet provided
- Draw diagrams using pencil
- A formulae sheet, data sheet and Periodic Table are provided SEPARATELY
- Write your Centre Number and Student Number at the top of this page

**Total marks: 100**

**Section I – 20 marks** (pages 2 – 9)
- Attempt Questions 1 – 20
- Allow about 35 minutes for this section

**Section II – 80 marks** (pages 10 – 29)
- Attempt Questions 21 – 35
- Allow about 2 hours and 25 minutes for this section

**Section I**
**20 marks**

**Attempt Questions 1 – 20**
**Allow about 35 minutes for this part**

Use the Multiple-Choice Answer Sheet for Questions 1 – 20.

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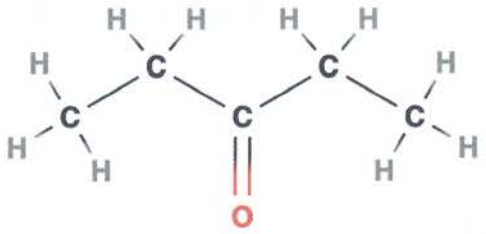
**1** What is the preferred name for the following molecule?



A. pentanal

B. pentanone

C. pentan-3-al

D. pentan-3-one

**2** A student performed the following steps.

1. A piece of graphite was burnt in excess oxygen.
2. The gas produced was collected and bubbled through limewater.
3. The precipitate was filtered and dried.
4. The precipitate was treated with phosphoric acid.
5. The volume of gas produced was measured.

Which equation best represents one of the steps in the experiment?

A. $CO_2(g) + Ca(OH)_2(aq) \rightleftharpoons CaCO_3(s) + H_2O(l)$

B. $2CaCO_3(aq) + 2H_3PO_4(aq) \rightleftharpoons Ca_2(PO_4)_2(aq) + 3CO_2(g) + 3H_2O(l)$

C. $3CaCO_3(aq) + 2H_3PO_4(aq) \rightleftharpoons 2Ca(PO_4)_2(s) + 3CO_2(g) + 3H_2O(l)$

D. $3CaCO_3(aq) + 2H_3PO_4(aq) \rightleftharpoons Ca_2(PO_4)_2(aq) + 3CO_2(g) + 3H_2O(l)$

3 Chlorine gas is bubbled through hept-2-ene and a reaction occurs. What is the main product of this reaction?

A. 1-chloroheptane

B. 2-chloroheptane

C. 1,2-dichloroheptane

D. 2,3-dichloroheptane

4 Using your data table, which of the following options shows the correct order of increasing solubility of $Pb^{2+}$ ions in the following salt solutions?

| | | | | |
|---|---|---|---|---|
| A. | $PbCl_2$ | $PbBr_2$ | $PbCO_3$ | $Pb_3(PO_4)_2$ |
| B. | $Pb_3(PO_4)_2$ | $PbCO_3$ | $PbBr_2$ | $PbCl_2$ |
| C. | $PbCO_3$ | $Pb_3(PO_4)_2$ | $PbCl_2$ | $PbBr_2$ |
| D. | $PbBr_2$ | $PbCl_2$ | $Pb_3(PO_4)_2$ | $PbCO_3$ |

5 Which statement is NOT true for a mixture of ice and water at equilibrium at a constant temperature?

A. There are equal amounts of ice and water

B. The rates at which melting and freezing occur are equal

C. The system at equilibrium shows no macroscopic change

D. When the water is cooled, and the ice is heated, the same position of equilibrium can be achieved

6 Which of the following is amphiprotic?

A. $NH_4^+$

B. $HSO_3^{2-}$

C. $HPO_4^{2-}$

D. $H_3PO_4$

**7** Which of the following occurs when grease is mixed with soapy water?

A. The hydrophilic tail of the soap bonds to the grease.

B. The hydrophobic head of the soap bonds to the grease.

C. The hydrophobic ends of the soap and the grease bond.

D. The head of the hydrophilic soap bonds to the hydrophilic grease.

**8** The compound HCFC-123 has the molecular formula $C_2F_3Cl_2H$. It is an alternative to CFC-11 in low pressure refrigeration, as it is better for the ozone layer.

How many isomers have the formula $C_2F_3Cl_2H$?

A. 1

B. 2

C. 3

D. 4

Question 9 and Question 10 refer to the following information.

**9** Butyl acetate can be synthesised and purified in the school laboratory. The initial step is usually to reflux the reactants.

Which of the following is NOT a suitable safety precaution for this initial step?

A. Students should wear safety glasses and lab coats, to protect from any spills.

B. The concentrated sulfuric acid should be handled with gloves, as it is very corrosive.

C. A thermometer should be inserted in the top of the condenser, to monitor the temperature.

D. Naked flames should be avoided near the reactants, as organic chemicals may be combustible.

**10** The yield from the reaction is only 35%.

What is the maximum yield of the ester if 10.5 g of acetic acid is reacted with 9.5 g of 1-butanol?

A. 5.2 g

B. 7.0 g

C. 7.1 g

D. 20.0 g

**11** Which $K_{eq}$ expression is correct for the following reaction?

$Cu^{2+} + SCN^{-} \rightleftharpoons CuSCN^{+}$

A. $\dfrac{[Cu^{2+}]\,[SCN^{-}]}{[CuSCN^{+}]}$

B. $\dfrac{[Cu]^2\,[SCN^{-}]}{[CuSCN^{+}]}$

C. $\dfrac{[CuSCN^{+}]}{[Cu^{2+}][SCN^{-}]}$

D. $\dfrac{[CuSCN^{+}]}{[Cu]^2[SCN^{-}]}$

**12** Which of the following pairs of substances will NOT form an equilibrium?

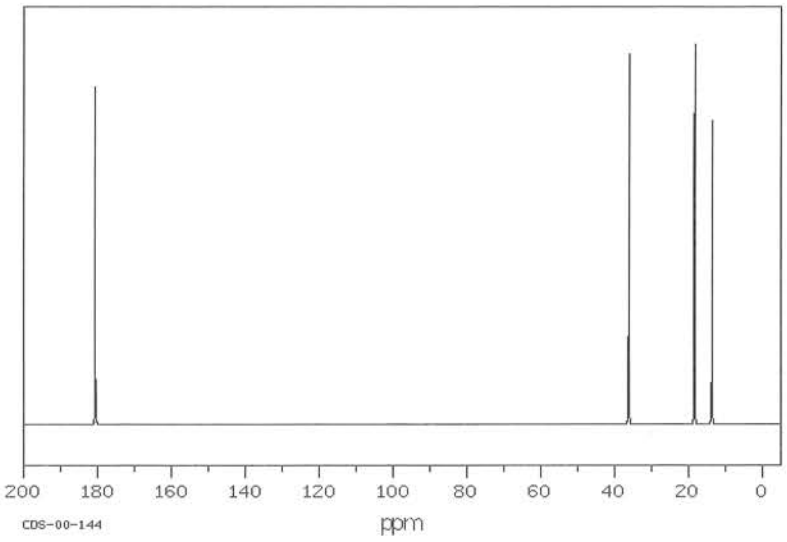
A. $CH_3CH_2NH_2$ (aq) / $CH_3CH_2NH_3^+$ (aq)

B. NaH(aq) / $H_2$ (g)

C. $SO_4^{2-}$(aq) / $H_2SO_4$ (aq)

D. $NH_3$ (aq) / $NH_4^+$ (aq)

**13** The carbon-13 NMR spectrum of an organic molecule is shown below.




Which molecule could produce this spectrum?

A. Butane

B. Butanoic acid

C. Methyl butanoate

D. Propanoic acid

**14** The flow chart below shows that propene undergoes a hydration reaction to form compound X. Compound X is then oxidised to form propanone.


Which of the following correctly identifies compound X?

A. Propan-1-ol

B. Propan-2-ol

C. 2-methylpropan-1-ol

D. 2-methylpropan-2-ol

**15** 20.0 mL of 0.10 mol $L^{-1}$ sodium hydroxide was added to 10.0 mL of 0.20 mol $L^{-1}$ sulfuric acid and 10.0 mL of distilled water. Determine the temperature increase of the solution.

( $\Delta H_{neutralisation} = -57$ kJ $mol^{-1}$)

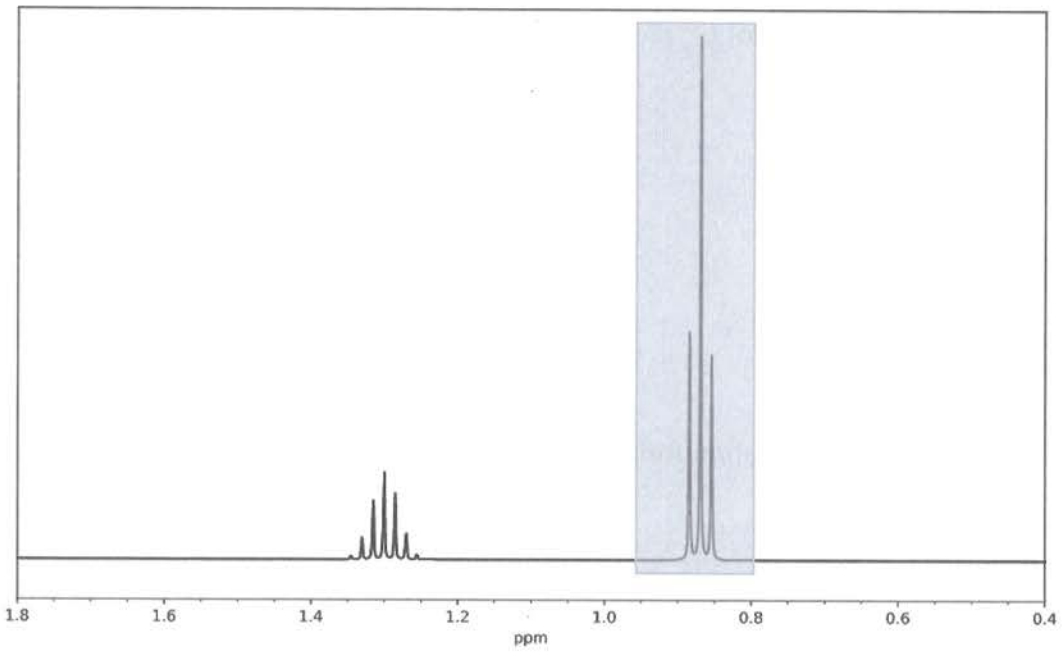
A. 0.51°C

B. 0.68°C

C. 1.14°C

D. 1.37°C

**16** The proton NMR spectrum of propane is shown below.




What does the shaded part of the spectrum show?

A. A triplet splitting pattern, indicating the presence of two hydrogens on the neighbouring carbons

B. A quartet splitting pattern, indicating the presence of three hydrogens on the neighbouring carbons

C. A quartet splitting pattern, indicating the presence of two hydrogens on the neighbouring carbons

D. A triplet splitting pattern, indicating the presence of four hydrogens on the neighbouring carbons

**17** What is the minimum amount of solid barium nitrate ($M_r$ 271.3 g $mol^{-1}$) that needs to be added to 50.0 mL of sodium hydroxide (0.0500 mol $L^{-1}$) to cause precipitation?

A. 0.339 g.

B. 0.678 g.

C. 1.38 g.

D. 2.77 g.

**18** Question 18 and 19 refer to the following information.

Propanoic acid ($C_2H_5COOH$) has pKa of 4.87.

What is the pH of 0.010 mol $L^{-1}$ propanoic acid solution at 25°C?

A. 2.00

B. 3.44

C. 4.87

D. 5.87

**19** What is the percent dissociation for this solution of propanoic acid?

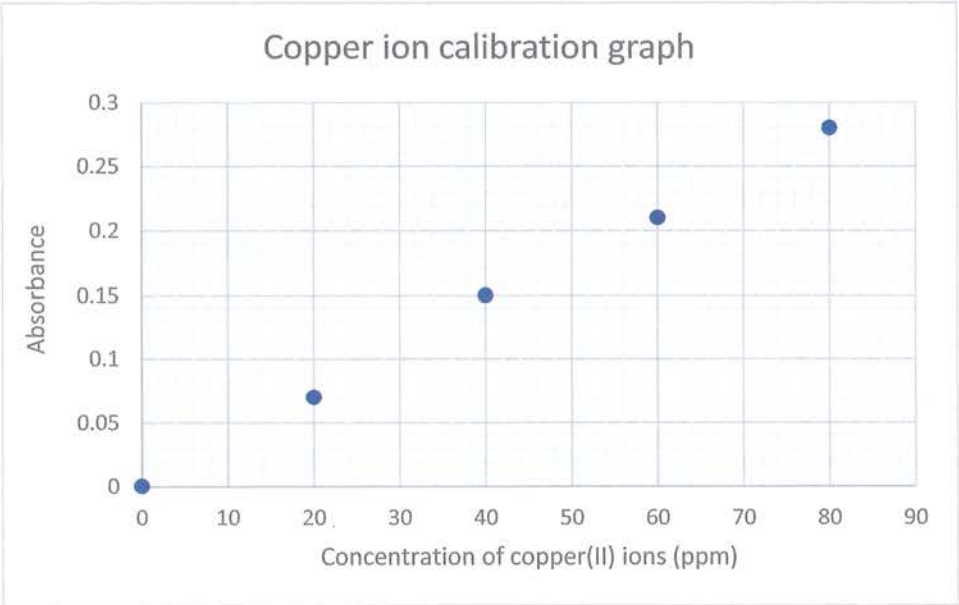
A. 0.01

B. 0.13

C. 0.36

D. 3.67

**20** A student was analysing two solutions of copper(II) chloride with unknown concentration. The student's calibration curve for this analysis is shown below.




The student measured the absorbances of the two solutions of unknown concentration.

| | |
|---|---|
| Absorbance of **Solution 1** | 0.25 |
| Absorbance of **Solution 2** | 0.15 |

What was the chloride ion concentration in Solution 2 (in mol $L^{-1}$)?

A. $2.98 \times 10^{-4}$

B. $4.00 \times 10^{-4}$

C. $6.29 \times 10^{-4}$

D. $1.26 \times 10^{-3}$

**Section II**
**80 marks**

**Attempt Questions 21 – 35**
**Allow about 2 hours and 25 minutes for this section**

- 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 on page 30 – 31. If you use this space, clearly indicate which question you are answering.

**Question 21** (4 marks)

Determine if a precipitate forms when 150 mL of 0.10 M $Pb(NO_3)_2$ is combined with 100 mL of 0.20 M NaCl. **4**

**Question 22** (5 marks)

(a) Outline two advantages of using biofuel compared to fossil fuels. **2**

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(b) Ethanol's use as a biofuel is becoming increasingly common. **3**

The table below shows various properties of ethanol.

| Properties of Ethanol | |
|---|---|
| Heat of Combustion (kJ $mol^{-1}$) | 1370 |
| Density (g $mL^{-1}$) | 0.78 |
| Average molar mass (g $mol^{-1}$) | 46 |

A vehicle has a 60 L fuel tank.

Calculate the energy released by the complete combustion of one full tank of ethanol.

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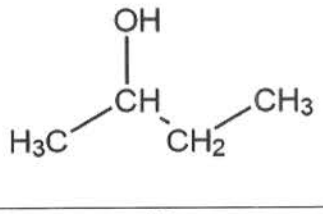
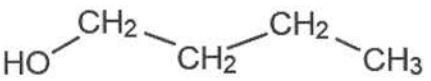
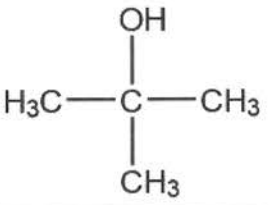
**Question 23** (9 marks)

Below are three different compounds.

| X | Y | Z |
|---|---|---|
|  |  |  |

(a) Name **Compound Y**. **1**

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(b) Define the term "*homologous series*" using one or more of the compounds as an example. **2**

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(c) Define the term "*position isomers*" using one or more of the compounds as an example. **2**

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(d) Each of the compounds is mixed with acidified potassium permanganate. Outline any reactions that may occur and identify any products that may form. **4**

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**Question 24** (4 marks)

Describe how to prepare 250.0 mL of a 0.150 mol $L^{-1}$ sodium borate octahydrate solution, $(Na_2[B_4O_5(OH)_4].8H_2O)$, and also how hydrochloric acid can be used to verify its concentration. **4**

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**Question 25** (4 marks)

A pharmaceutical company states that consuming two of their tablets provides 50% of the daily intake of calcium. The average daily intake of calcium is 1450 mg. The tablets contain soluble calcium in the form of calcium citrate ($Ca_3(C_6H_5O_7)_2$). Citric acid is a weak triprotic acid. **4**

One tablet was crushed, dissolved into 25.0 mL of distilled water and made up to 100.0 mL. A 10.0 mL sample required 37.0 mL of 0.160 mol $L^{-1}$ $H_3PO_4$ to precipitate the calcium.

Evaluate the company's claim.

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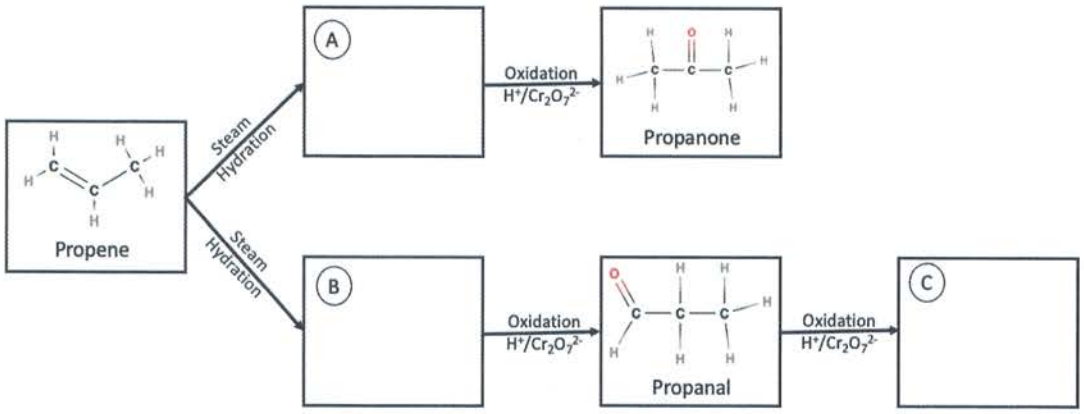
**Question 26** (5 marks)

(a) Propene, in the presence of a strong acid catalyst and high temperatures, undergoes a hydration reaction with steam. **3**




Complete the reaction pathway diagram above by providing structural formulae and naming compounds A, B and C.

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(b) Butanoic acid was placed in a reflux apparatus with compound B and concentrated sulfuric acid. The mixture was heated until a sweet fruity odour was observed. **2**

Write a balanced chemical equation for the reaction and name the products formed.

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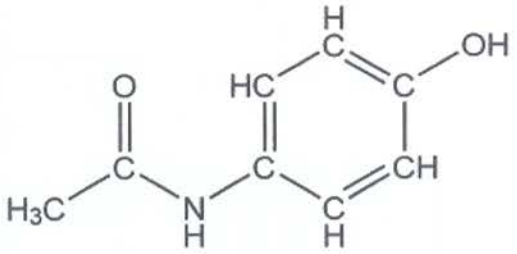
**Question 27** (8 marks)

Paracetamol is a compound that is commonly used in pain relief.

It has the chemical structure shown on the right.




If paracetamol is hydrolysed in the presence of an acid, it forms two compounds, **A** and **B**.

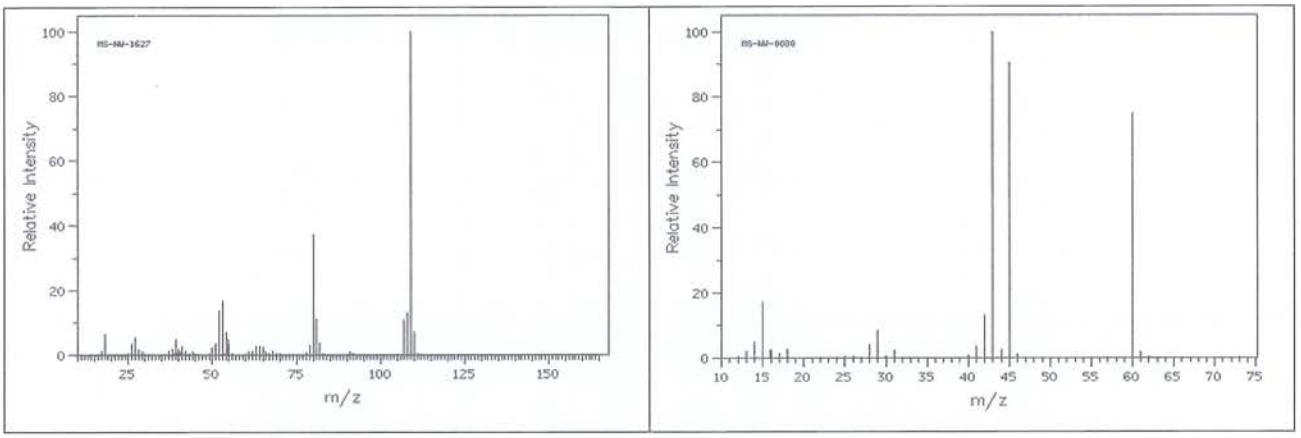
The unbalanced reaction can be represented by:

**paracetamol + water → A + B**

The following data was collected for both products.

| A | B |
|---|---|
| 66.0% carbon | 39.9% carbon |
| 6.5% hydrogen | 6.7% hydrogen |
| 12.8% nitrogen | 53.4% oxygen |
| 14.7% oxygen | |

Elemental analyses

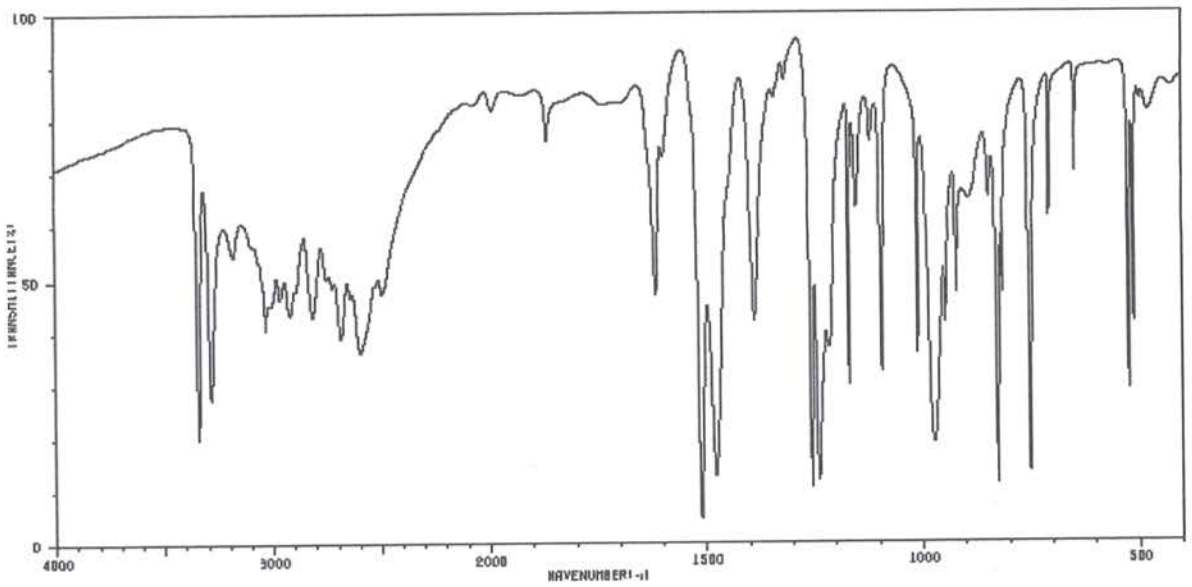



**Question 27 continues on page 17**

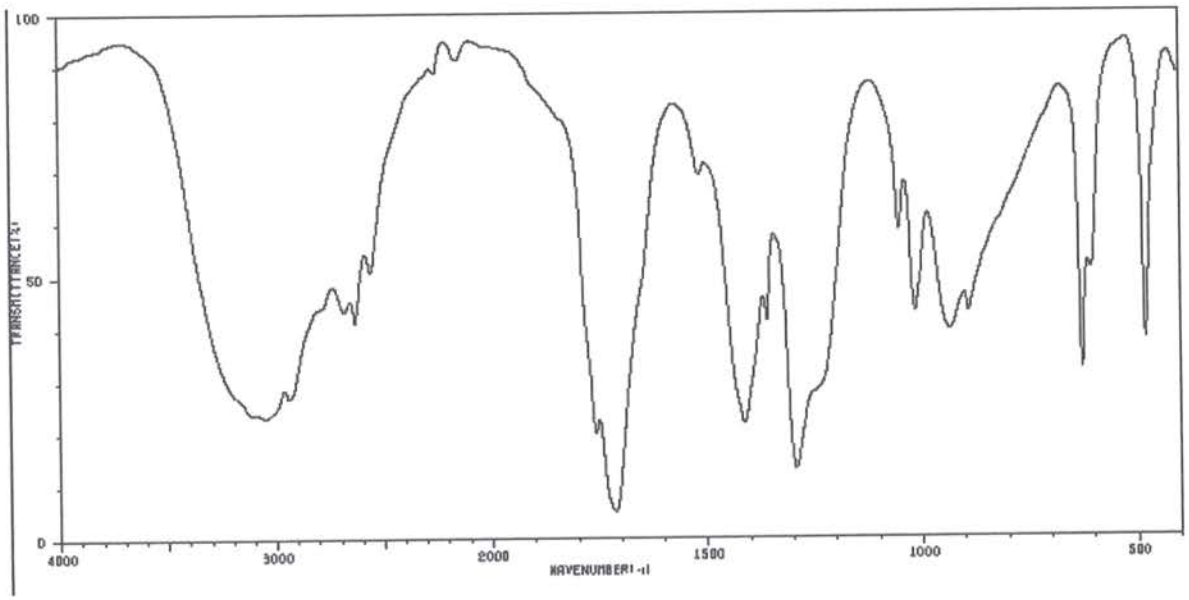
Question 27 (continued)

Infrared spectra

**A**




**B**




**Question 27 continues on the page 18**

Question 27 (continued)

(a) Determine the empirical formula of Compound A using the given data. **2**

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(b) Determine the molecular mass of Compound B. **1**

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(c) Using the chemical data sheet and the infrared spectra, identify and explain ONE important feature of each infrared spectrum that can be used to determine the structure of each compound. **3**

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(d) Draw the electron dot diagram of Compound B. **2**

**Question 28** (4 marks)

With reference to the synthesis of a named chemical, evaluate the impact of its production process on the environment. **4**

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**Question 29** (5 marks)

Although often written as the reverse of aerobic respiration, photosynthesis is a non-equilibrium reaction at room temperature, 25°C. **5**

Analyse this statement with reference to dynamic equilibrium and non-equilibrium systems and the entropy and enthalpy of photosynthesis.

| | $\Delta H^\circ_f$ kJ mol$^{-1}$ | $\Delta S$ J mol$^{-1}$ K$^{-1}$ |
|---|---|---|
| $CO_2$ | -394 | 214 |
| $H_2O$ | -286 | 70 |
| $C_6H_{12}O_6$ | -1264 | 210 |
| $O_2$ | | 205 |

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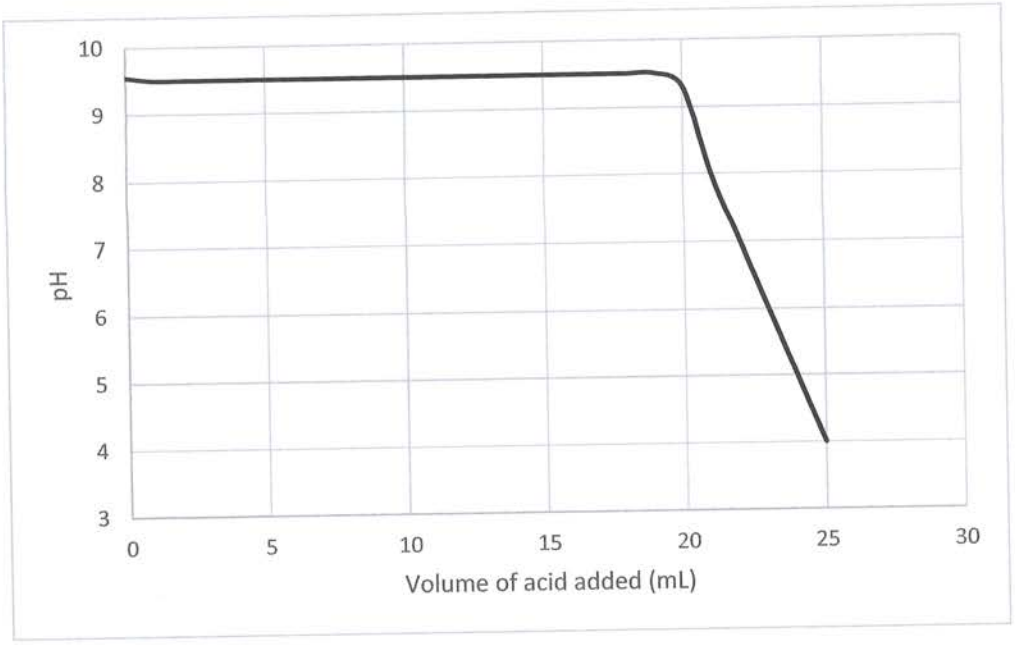
**Question 30** (6 marks)

(a) The graph shows how pH varies for this solution as acid is added to it. Explain the shape of the graph. **3**

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**Question 30 continues on page 22**

Question 30 (continued)

(b) This chemical process is important in various natural chemical systems. Using an appropriate equation, outline the chemistry involved in a named, natural system. **3**

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**Question 31** (7 marks)

A student suspected that a greenish-blue powder was copper(II) chloride. 7

Outline a suitable method, with expected results, to confirm that the powder is copper(II) chloride. Your method should include a flame test, a precipitation reaction and a complexation reaction.

**Question 31 continues on page 24**

Question 31 (continued)

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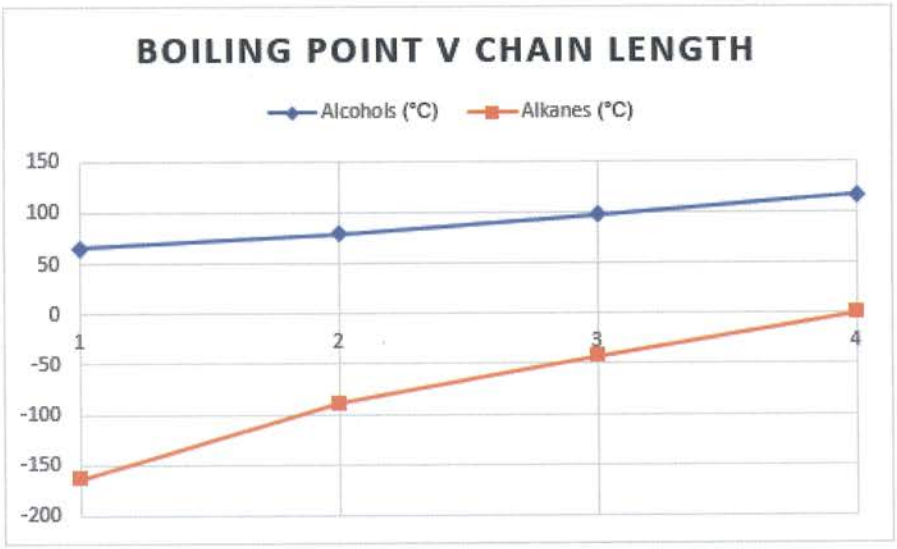
**Question 32** (4 marks)

The trend in boiling points for alkanes and alcohols is shown below. **4**

Using the data provided, account for the differences in boiling point within a homologous series AND between the two homologous series.

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**Question 33** (6 marks)

Students were asked to determine the concentration of a sample of acetic acid. They decided to carry out a titration with 0.102 mol $L^{-1}$ sodium hydroxide and 25.00 mL aliquots of acetic acid. The results are shown below.

| **Volume of 0.102 M sodium hydroxide v 25.0 mL aliquots of acetic acid** | | | |
|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 |
| Burette reading initial (mL) | 0.21 | 0.49 | 3.98 |
| Burette reading final (mL) | 26.00 | 25.80 | 29.23 |
| Volume used (mL) | | | |
| Indicator | | | |

(a) Complete the table above with the volumes used in each trial and an appropriate indicator for this titration. **2**

(b) The $K_a$ of the acid at 25°C is $1.7 \times 10^{-5}$. **4**

Use this information and that from part (a) to construct a titration curve for this reaction.

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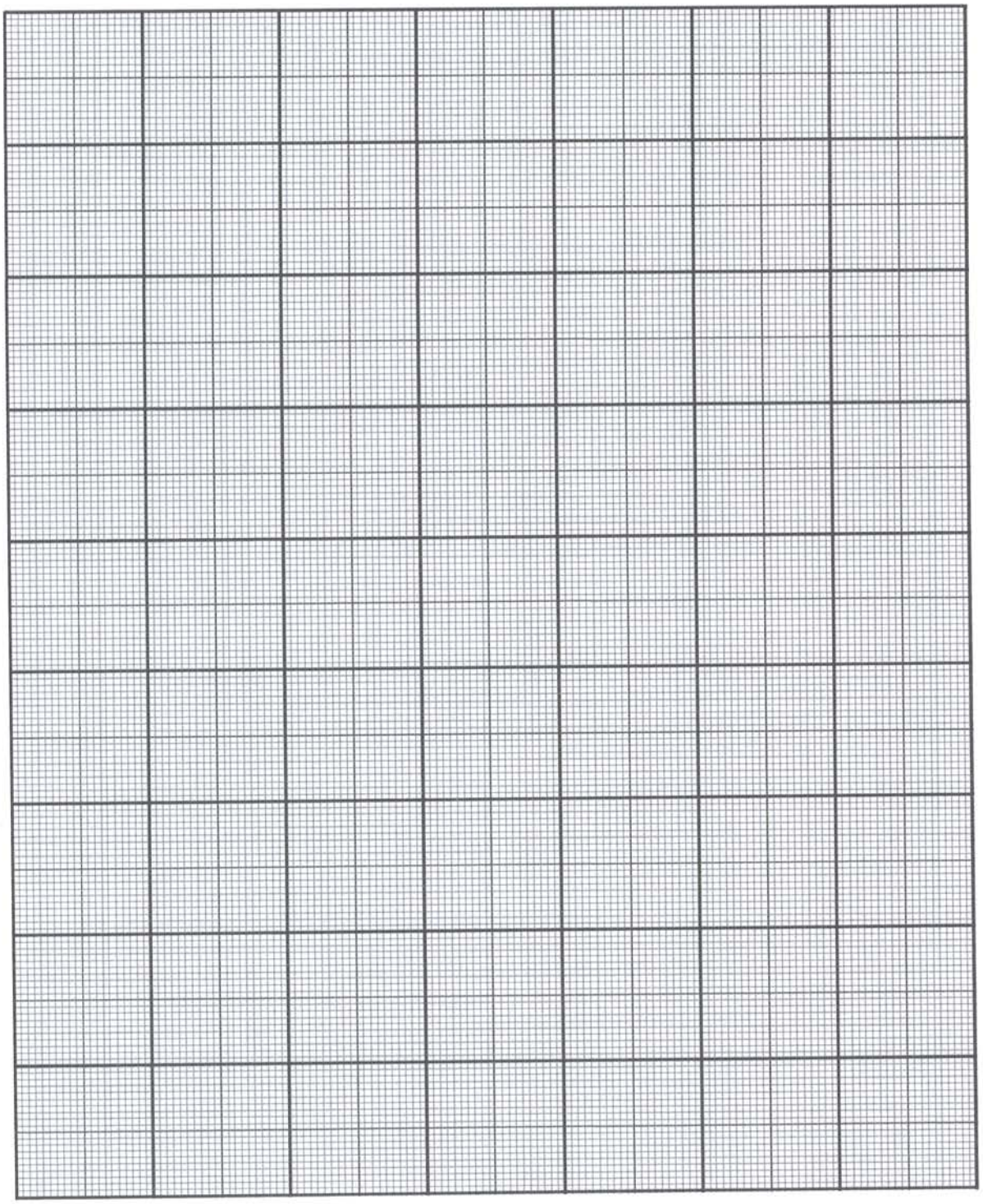
**Question 33 continues on page 27**

Question 33 (continued)



**Question 34** (6 marks)

Compare and account for any differences in the molar solubility of lead (II) iodide in (i) water, (ii) 0.1 M lead (II) nitrate and (iii) 0.1 M magnesium iodide. **6**

**Question 35** (3 marks)

Consider a solution of propanoic acid, $pK_a$ 4.88, in water at 25°C. **3**

Describe, using a suitable equation, what happens to the $K_a$ and degree of ionisation if the solution evaporates to half its volume at 25°C.

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**End of Examination**

**Section II extra writing space**

If you use this space, clearly indicate which question you are answering by writing the question number before beginning the response.

**Section II extra writing space**

If you use this space, clearly indicate which question you are answering by writing the question number before beginning the response.

## EXAMINERS

| | |
|---|---|
| Ernst Smeets (Convenor) | PLC Sydney, Croydon |
| Cassandra Aitken | St Edward's College, East Gosford |
| Andrew Eaton | Wollondilly Anglican College, Tahmoor |
| Scott Tibbey | MLC School, Burwood |
| Charlotte Young | Kincoppal - Rose Bay School of the Sacred Heart, Rose Bay |

CSSA

# 2022
## TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

**MARKING GUIDELINES**

# Chemistry

**Section I**
**20 marks**

**Questions 1-20** (1 mark each)

| Question | Answer | Outcomes Assessed | Targeted Performance Band |
|---|---|---|---|
| 1 | D | CH12-5, CH-12-14 | 2-3 |
| 2 | A | CH12-5 | 2-3 |
| 3 | D | CH12-6, CH12-14 | 2-3 |
| 4 | B | CH12-5, CH12-6, CH12-12 | 3-4 |
| 5 | A | CH12-6, CH12-12 | 3-4 |
| 6 | C | CH12-5, CH12-13 | 3-4 |
| 7 | C | CH12-6, CH12-7, CH12-14 | 3-4 |
| 8 | B | CH12-6, CH12-14 | 3-4 |
| 9 | C | CH12-3, CH12-14 | 2-3 |
| 10 | A | CH12-4, CH12-14 | 4-5 |
| 11 | C | CH12-5 | 3-4 |
| 12 | C | CH12-6 | 3-4 |
| 13 | B | CH12-6, CH12-15 | 3-4 |
| 14 | B | CH12-5, CH12-6, CH12-14 | 4-5 |
| 15 | B | CH12-6, CH12-12 | 4-5 |
| 16 | A | CH12-5, CH12-6, CH12-15 | 4-5 |
| 17 | A | CH12-5, CH12-6, CH12-12 | 5-6 |
| 18 | B | CH12-5, CH12-6, CH12-13 | 4-5 |
| 19 | D | CH12-6, CH12-13 | 4-5 |
| 20 | D | CH12-4, CH12-15 | 5-6 |

## Section II
## 80 marks

**Question 21** (4 marks)
***Outcomes Assessed: CH12-5, CH12-6***
***Targeted Performance Bands: 3-5***

| Criteria | Marks |
|---|---|
| • Uses correct chemical equation to calculate ionic product<br>AND<br>• Compares IP to $K_{sp}$ from data table to determine if ppt forms | 4 |
| • Uses correct chemical equation to incorrectly calculate ionic product<br>AND<br>• Compares IP to $K_{sp}$ from data table to determine if ppt forms | 3 |
| • Uses incorrect chemical equation to calculate IP<br>AND<br>• Compares IP to $K_{sp}$ from data table to determine if ppt forms | 2 |
| • Calculates incorrect IP and states if ppt forms (no reference to data table)<br>OR<br>• Some relevant information | 1 |

***Sample Answer:***

$PbCl_2\ (s) \rightleftharpoons Pb^{2+}(aq) + 2\ Cl^-\ (aq) \quad Ksp = 1.2 \times 10^{-5}$

mol $Pb^{2+}$ (aq) = (0.150 L)(0.10 mol $Pb^{2+}$/L) = 0.015 mol

$[Pb^{2+}] = 0.015$ mol/0.250 L = 0.060 M

mol $Cl^-$ (aq) = 0.100 L) (0.20 mol $Cl^-$/L) = 0.020 mol

$[Cl^-] = 0.020$ mol/0.250 L = 0.080 M

Ionic Product, $Q = [Pb^{2+}][Cl^-]^2 = (0.060)(0.080)^2 = 3.8 \times 10^{-4}$

$Q > K_{sp}$, so $PbCl_2$ will precipitate from solution.

**Question 22** (5 marks)
(a) (2 marks)
***Outcomes Assessed: CH12-14***
***Targeted Performance Bands: 2-4***

| Criteria | Marks |
|---|---|
| • Provides two advantages for using ethanol as a biofuel | 2 |
| • Provides one advantage | 1 |

***Sample Answer:***

Biofuels, such as ethanol are produced from renewable resources and therefore not be depleted, like fossil fuels. Biofuels are essentially carbon neutral, as the carbon dioxide produced in their combustion is re-used in photosynthesis.

(b) 3 marks
***Outcomes Assessed: CH12-14***
***Targeted Performance Bands: 3-5***

| Criteria | Marks |
|---|---|
| • Correctly calculates the energy released | 3 |
| • Provides substantially correct working out towards calculating the energy released | 2 |
| • Provides some relevant understanding | 1 |

***Sample Answer:***

Density = mass/volume
Mass (ethanol) = density x volume
= 0.78 g/mL x 60 L x 1000 mL/L
= 46800g

Moles (ethanol) = mass/molar mass
= 46800 / 46
= 1071.3913 mol

Energy released = moles x heat of combustion
= 1017.3913 mol x 1370 kJ/mol
= 1393826.09 kJ
= 1400 MJ

**Question 23** (5 marks)

(a) 1 mark

***Outcomes Assessed: CH12-14***

***Targeted Performance Bands: 2-3***

| Criteria | Marks |
|---|---|
| • Correctly identifies the compound | 1 |

***Sample Answer:***

1-butanol or butan-1-ol.

(b) 2 marks

***Outcomes Assessed: CH12-14***

***Targeted Performance Bands: 2-3***

| Criteria | Marks |
|---|---|
| • Correctly defines the term homologous series<br>• Correctly uses one or more of the compounds as an example | 2 |
| • Provides some relevant information | 1 |

***Sample Answer:***

A homologous series is a set of compounds with the same functional group, just with differing numbers of carbons. Compound Y is part of the primary alcohol homologous series with general formula $C_nH_{2n+1}OH$.

(c) 2 marks

***Outcomes Assessed: CH12-14***

***Targeted Performance Bands: 2-3***

| Criteria | Marks |
|---|---|
| • Correctly defines the term position isomer<br>• Correctly uses one or more of the compounds as an example | 2 |
| • Provides some relevant information | 1 |

***Sample Answer:***

Position isomers have the same chemical formula and the same functional group, but the functional group is located on a different part of the carbon skeleton. Compound X and Compound Y both have 4 carbons in a linear chain and a hydroxyl group, but the hydroxyl group is in a different position on the chain.

(d) 4 marks

***Outcomes Assessed: CH12-14***

***Targeted Performance Bands: 3-4***

| Criteria | Marks |
|---|---|
| • Correctly identifies the products formed from the oxidation of Compounds X and Y AND<br>• Correctly identifies no reaction with Compound Z | 3-4 |
| • Correctly identifies ONE product from the oxidation of Compounds X and Y OR<br>• Correctly identifies that both Compounds X and Y will react, but Compound Z will not react | 2 |
| • Provides some relevant information | 1 |

***Sample Answer:***

Compound X is a secondary alcohol, so will oxidise with acidified potassium permanganate to form a ketone, butanone. Compound Y is a primary alcohol, so will oxidise with acidified potassium permanganate (a strong oxidising agent) to form a carboxylic acid, butanoic acid. Compound Z is a tertiary alcohol, so will not react with acidified potassium permanganate.

**Question 24** (4 marks)
***Outcomes Assessed: CH12-2, CH12-13***
***Targeted Performance Bands: 4-5***

| Criteria | Marks |
|---|---|
| • Describes a suitable method, including required mass of dried solid, dissolution in minimum distilled water, transfer to volumetric flask which is filled to the mark and agitated to ensure mixing.<br>• Verification using known concentration of HCl and a suitable indicator to titrate known volume of boric acid and appropriate calculation with 1:4 mol ratio | 5-6 |
| • As above, but missing two major steps | 3-4 |
| • Describes a method and states how HCl can be used in a titration | 2 |
| • Provides some relevant information | 1 |

***Sample Answer:***

Preparation
The required mass (or similar, known mass) of sodium borate octahydrate (0.150 mol $L^{-1}$ x 0.250 L x 301.2 g $moL^{-1}$ = 11.30 g) is dissolved in a small volume of distilled/deionised water. This is carefully transferred, using a funnel, into a clean 250.0 mL volumetric flask. Distilled water is added up to the graduation mark and the solution is inverted to ensure complete mixing occurs.

Verification
Sodium borate is a base containing 4 OH groups, therefore a strong acid, such as hydrochloric acid can be used to verify the concentration of the solution using titration.
For example, a 0.150 M solution contains 0.150 x 0.020 = 3.00 x $10^{-4}$ moles per 20.00 mL. That 20.00 mL sample will require 4 times as many mol of HCl. If this many mol are used, then the solution is 0.150 mol $L^{-1}$ sodium borate octahydrate.

**Question 25** (4 marks)
***Outcomes Assessed: CH12-2, CH12-5***
***Targeted Performance Bands: 4-5***

| Criteria | Marks |
|---|---|
| • Evaluates the claim correctly by calculating the actual amount of calcium in two tablets and comparing it to the claim. | 4 |
| • Evaluates the claim based on a calculation that has one error<br>OR<br>• Evaluates the claim based on an incorrect equation and no calculation error | 3 |
| • Determines mass of calcium for one tablet | 2 |
| • Determines the mass of calcium using incorrect equation<br>OR<br>• Writes correct equation for precipitation | 1 |

***Sample Answer:***

$3Ca^{2+}(aq) + 2PO_4^{-3}(aq) \rightarrow Ca_3(PO_4)_2(s)$

Mol of phosphate added. $= 0.0370 \times 0.16$

$= 0.00592$ mol

Mol of calcium ions = 3/2 x mol of phosphate = 0.00888 mol

Mass of Ca = $40.08 \times 0.00888$

$= 0.3559$ g

Mass in mg per tablet = 356 mg

Mass of 2 tablets = $356 \times 2 = 712$ mg

The company's statement is incorrect, as the amount of Calcium per tablet is 356 mg. Two tablets contain 712 mg which is below the quoted amount: 50% of 1450 = 725 mg, so the claims of the manufacture are false.

**Question 26** (6 marks)

(a) 3 marks

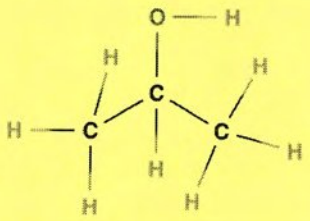
***Outcomes Assessed: CH12-14***

***Targeted Performance Bands: 2-4***

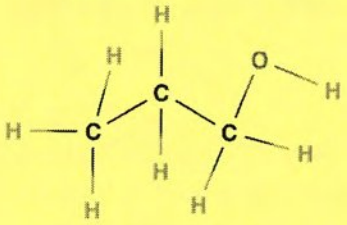
| Criteria | Marks |
|---|---|
| • Provides correct structural formulae and names for compound A, B and C | 3 |
| • TWO of the above | 2 |
| • ONE of the above | 1 |

***Sample Answer:***

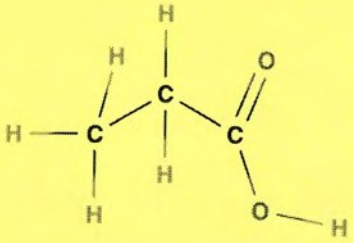
**Compound A - Propan-2-ol**



**Compound B - Propan-1-ol**



**Compound C - Propanoic Acid**



(b) 2 marks

***Outcomes Assessed: CH12-14***

***Targeted Performance Bands: 2-4***

| Criteria | Marks |
|---|---|
| • Provides a correctly balanced symbol equation and names the products | 2 |
| • Writes correct equation (states not required)<br>OR<br>• Names the products | 1 |

***Sample Answer:***

$C_4H_8O_2 + C_3H_8O \rightleftharpoons C_7H_{14}O_2 + H_2O$ (condensed structural formula accepted)

Products – Propyl butanoate and water

**Question 27** (8 marks)
***Outcomes Assessed: CH12-14, CH12-15***
***Targeted Performance Bands: 2-4***
(a) 2 marks

| Criteria | Marks |
|---|---|
| • Correctly determines the empirical formula | 2 |
| • Provides some relevant information | 1 |

***Sample Answer:***

In 100 g, there are

| | | | |
|---|---|---|---|
| 66.0 g of carbon | 6.5 g of hydrogen | 12.8 g of nitrogen | 14.7 g of oxygen |
| = 66.0/12.0 mol of C | = 6.5/1.008 mol of H | = 12.8/14.01 mol of N | = 14.7/16.01 mol of O |
| = 5.5 mol of C | = 6.45 mol of H | = 0.914 mol of N | = 0.918 mol of O |

Therefore,
n(C): n(H): n(N): n(O) = 5.5:6.45:0.914:0.918 (divide by 0.914)
= 6.0:7.1:1:1.0
= 6:7:1:1 (whole numbers)
The empirical formula is $C_6H_7NO$

***Outcomes Assessed: CH12-14, CH12-15***
***Targeted Performance Bands: 2-4***
(b) 1 mark

| Criteria | Mark |
|---|---|
| • Correctly determines the molecular mass of Compound B | 1 |

***Sample Answer:***

Based on the mass spectrum, the molecular mass is 60 g/mol.

***Outcomes Assessed: CH12-14, Ch12-15***
***Targeted Performance Bands: 2-5***
(c) 3 marks

| Criteria | Marks |
|---|---|
| • Correctly identifies and explains ONE important feature for each compound | 3 |
| • Correctly identifies ONE important feature for each compound<br>OR<br>• Correctly identifies and explains ONE feature for each compound | 2 |
| • Provides some relevant information | 1 |

***Sample Answer:***

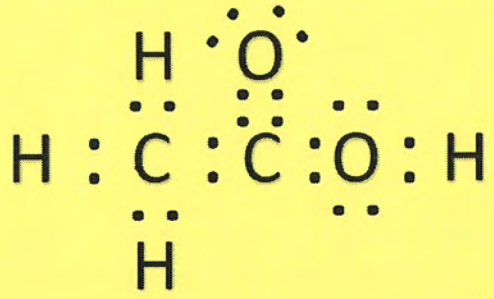
For Compound A, there is a sharp peak at 3350 $cm^{-1}$, indicating a N-H amine bond. (1630 $cm^{-1}$ would indicate a C=C bond, but this would not really help unlock the structure of Compound A, given the structure of paracetamol. There are two peaks around 3300 $cm^{-1}$ and 3350 $cm^{-1}$. Normally the -OH alcohol bond is broad, so these sharper peaks are not good for identifying the-OH structure). For Compound B, there is a very broad band centred on 3000 $cm^{-1}$, indicative of an acidic -OH group. (There is also a peak at 1700 $cm^{-1}$, but given the C=O in the structure of paracetamol, this does not help a great deal in determining the structure of Compound B).

***Outcomes Assessed: CH!2-14, CH12-15***
***Targeted Performance Bands: 2-3***

(d) 2 marks

| Criteria | Marks |
|---|---|
| • Correctly draws the electron dot diagram | 2 |
| • Provides most elements of the electron dot diagram | 1 |

***Sample Answer:***



**Question 28** (4 marks)
***Outcomes Assessed: CH12-15***
***Targeted Performance Bands: 4-6***

| Criteria | Marks |
|---|---|
| • Discusses the impact of the production process on the environment<br>AND<br>• Discusses the need for the production process<br>AND<br>• Provides a judgement on the impact of the production process on the environment | 4 |
| • Provides ONE impact and AND ONE reason on the importance of the chemical<br>OR<br>• Provides ONE impact/reason on the importance of the chemical AND provides a judgement | 3 |
| • Provides ONE impact on the environment<br>OR<br>• Provides ONE reason on the importance of the chemical | 2 |
| • Any relevant information | 1 |

***Sample Answer:***

Ammonia is produced by reacting nitrogen and hydrogen in a synthesis called the Haber process. Ammonia has many applications and is widely relied upon by society to make fertilisers, plastics, cleaning products etc. The production of it can result in negative impacts on the environment. For example, the power required to generate the correct temperatures and high pressures to produce ammonia uses mostly fossil fuels, generating greenhouse gases. The sourcing of reactants produces greenhouse gases which further contributes to global warming. A great advantage of the process is that there is only one product from the synthesis, so the atom economy is high, and no waste chemical is formed. Although the production of ammonia has a negative impact on the environment, the utilisation of ammonia in industry has had an overwhelming positive impact on society.

**Question 29** (5 marks)
***Outcomes Assessed: CH12-7, CH12-12***
***Targeted Performance Bands: 3-5***

| Criteria | Marks |
|---|---|
| • Details features of equilibrium v non-equilibrium systems using correct terminology<br>AND<br>• Relates spontaneity to reaction enthalpy and entropy to each process<br>AND/OR<br>• Calculates **ΔG** using provided data and relates positive value to a non-spontaneous process for photosynthesis | 4-5 |
| • Provides some features of equilibrium and non-equilibrium systems<br>AND<br>• Identifies the enthalpy or entropy change for photosynthesis | 3 |
| • Provides some features of equilibrium and non-equilibrium systems<br>OR<br>• Identifies the enthalpy or entropy change for photosynthesis | 2 |
| • Provides relevant information | 1 |

***Sample Answer:***

Although the photosynthesis reaction can be seen via the equation to be the reverse of respiration the two reactions are not part of an equilibrium system and are distinctly different processes.
A dynamic equilibrium is one that is spontaneous and reversible, a non-equilibrium system is one in which the reactions only occur in one direction to make the products and does not spontaneously shift back to the reactants. As photosynthesis takes place in plant cells where chemicals are moved within the cell depending on the reaction required, it is an open system (not a closed system which is required for a dynamic equilibrium).
The process of photosynthesis is endothermic ($\Delta H_{reaction} > 0$) with the required energy being supplied by the absorption of energy from the sun. The glucose molecule, being a more complex molecule than the starting components means that order within the system has been increased which means a decrease in entropy occurs within the system ($\Delta S_{reaction} < 0$). As energy is required for the process and as entropy is decreased this then results in the Gibbs free energy, $\mathbf{\Delta G = \Delta H - T \Delta S}$ being positive.
For a reaction to be spontaneous, Gibbs free energy has to be less than zero.
Therefore, due to these factors photosynthesis is not an equilibrium reaction and is not the reverse of aerobic respiration.

**Question 30** (6 marks)
***Outcomes Assessed: CH12-5***
***Targeted Performance Bands: 3-5***
(a) 3 marks

| Criteria | Marks |
|---|---|
| • Explains the shape of a curve due to buffering – enough base is available to use up added $H^+$ until 20 mL of acid is added<br>AND<br>• This curve demonstrates high buffering capacity<br>AND<br>• Buffering capacity is reduced after 20 mL as the acid added is now in excess, resulting in rapid pH decrease | 3 |
| • Identifies that there is a buffer.<br>• State buffer ion (base component has been used up) | 2 |
| • Identifies that the solution is a buffer/buffering is occurring. | 1 |

***Sample Answer:***

As acid is added to the solution there is a resistance to the change in pH, so it is acting as a buffer. Buffers contain significant concentrations of the base and its conjugate acid (or a weak acid and its conjugate base). As the acid continues to be added the base component of the buffer (hydrogen acceptor) is being used up and runs out when the curve descends after 20 mL. At this point the solution can longer resist the change in pH, so the solution pH rapidly drops as the concentration of $H^+$ increases.

***Outcomes Assessed: CH12-5, CH12-13***
***Targeted Performance Bands: 3-5***
(b) 3 marks

| Criteria | Marks |
|---|---|
| • States valid equilibrium equation for a natural system<br>• Explains what happens if acid is added and if base is added.<br>• Clear statement about the shift in the equilibrium | 3 |
| • States valid equilibrium equation<br>• States what happens if acid is added and if base is added | 2 |
| • Names a buffer system | 1 |

***Sample Answer:***

Blood contains several buffers, one of which is the carbonic acid, $H_2CO_3$ (aq)/hydrogen carbonate ion, $HCO_3^-$ (aq) equlibrium. This buffer contains both the base and the conjugate acid in significant concentrations, enabling the equilibrium to shift left or right as required, to maintain blood pH at approximately 7.4.

Reaction 1: Acting as a base when extra acid is added

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

Reaction 2: Acting as an acid when base is added

$$OH^-(aq) + H_2CO_3(aq) \rightleftharpoons HCO_3^-(aq) + H_2O(aq)$$

When a small amount of acid is added the hydrogen carbonate reacts to minimise the change in pH. Reaction 1 will occur.

If a base is added the carbonic acid will react to minimise the change in pH. Reaction 2 will occur.

**Question 31** (7 marks)
***Outcomes Assessed: CH12-15***
***Targeted Performance Bands: 2-6***

| Criteria | Marks |
|---|---|
| • Outlines valid methods, with approximate quantities, for BOTH copper and chloride<br>• Provides valid observations, including colour, for confirmation<br>• Includes a flame test, precipitation reaction AND a complexation reaction | 6-7 |
| • Meets MOST of the above criteria | 4-5 |
| • Meets SOME of the above criteria | 2-3 |
| • Provides some relevant information | 1 |

***Sample Answer:***

*Method – testing for copper*

1) Place a pea-sized sample of the powder on a watch glass.
2) Wet a metal loop with some distilled water and coat it with the powder.
3) Place the coated metal loop into the tip of the blue Bunsen flame. If it is copper, the flame should turn blue-green.
4) Place a pea-sized sample of the powder into a test tube a fill the test tube with distilled water, to a depth of 5 cm. Stir to dissolve.
5) Add a few drops of 3.0 M ammonia solution and a pale blue copper hydroxide precipitation should form.
6) Add more ammonia solution until the precipitate dissolves and the copper returns to solution as a deep blue ammonia complex.

*Method – testing for chloride*

7) Place a pea-sized sample of the powder into a test tube a fill the test tube with distilled water, to a depth of 3 cm. Stir to dissolve.
8) Add a few drops of 0.1 M silver nitrate. A greyish-brown silver chloride precipitate should form.

**Question 32** (4 marks)
***Outcomes Assessed: CH12-14***
***Targeted Performance Bands: 3-5***

| Criteria | Marks |
|---|---|
| • Correctly accounts for the trend in both homologous series<br>AND<br>• Correctly identifies the different in bonding between the two homologous series<br>AND<br>• Correctly links strength of bond to the boiling point | 4 |
| • Correctly accounts for the trend in both homologous series<br>AND<br>• Correctly identifies the different in bonding between the two homologous series<br>OR<br>• Correctly accounts for the trend in both homologous series<br>AND<br>• Correctly links strength of bond to the boiling point | 3 |
| • Correctly accounts for the trend in both homologous series | 2 |
| • Any relevant information | 1 |

***Sample Answer:***

Both homologous series show an increase in boiling point as chain length increases. This is due to an increase in the number of dispersion forces between molecules. More energy is required to break the increasing number of forces. Alkanes only contain weak dispersion forces between molecules whereas alcohols can also form stronger hydrogen bonds between molecules. Hydrogen bonds require more energy to break than dispersion forces hence alcohols with the same number of carbons have higher boiling point than their respective alkane. As the chain length increases the increasing amount of dispersion forces becomes more significant, resulting in the boiling points for the series becoming closer.

**Question 33** (6 marks)

(a) 1 mark

***Outcomes Assessed: CH12-2***

***Targeted Performance Bands: 2-4***

| Criteria | Marks |
|---|---|
| • Completes volume used and identifies appropriate indicator | 2 |
| • Completes volume used or identifies appropriate indicator | 1 |

***Sample Answer:***

| Volume used (mL) | Trial 1 | Trial 2 | Trial 3 |
|---|---|---|---|
| | 25.79 | 25.31 | 25.25 |
| Indicator | Phenolphthalein | | |

(b) (4 marks)

***Outcomes Assessed: CH12-2, CH12-5, CH12-13***

***Targeted Performance Bands:2-6***

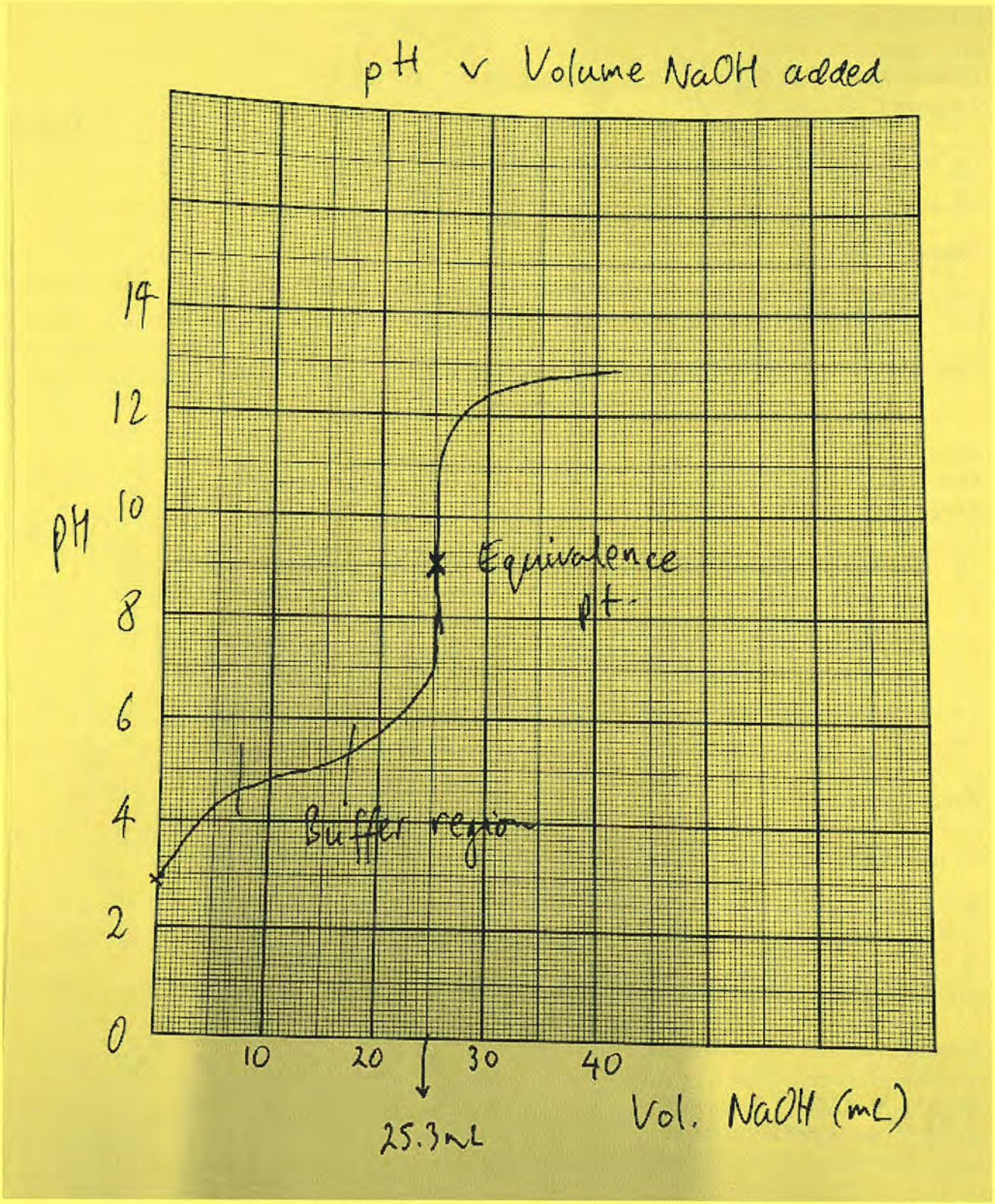
| Criteria | Marks |
|---|---|
| • Constructs a typical, labelled curve for weak acid/strong base starting at correct pH calculated from $K_a$ and showing volume of NaOH at equivalence point matching the average vol from (a) | 4 |
| • As above but has incorrect starting pH based on calculation from $K_a$ OR has incorrect volume at equivalence point | 3 |
| • Draws a typical curve for weak acid/strong base | 2 |
| • Draws a titration curve | 1 |

***Sample Answer:***

Average titration volume is 25.28 mL. This is the volume at the equivalence point.

$K = 1.7 \times 10^{-5} = XxX/0.1-X$
$X^2 = 0.1 \times 1.7 \times 10^{-5}$
$X = [H^+] = 0.0013$ mol $L^{-1}$
pH = 2.89 This will be the initial pH

x-axis has volume of NaOH (mL)
y-axis is pH from 0-14 or similar
starting pH is 2.9 (or close to it)
buffer region is part of the curve
equivalence point is around 9-10 at correct volume.



**Question 34** (6 marks)
***Outcomes Assessed: CH12-4, CH12-6, CH12-12***
***Targeted Performance Bands: 3-6***

| Criteria | Marks |
|---|---|
| • Correctly calculates the three solubilities, ranking them<br>AND<br>• Accounts in detail for differences in solubility for each salt in terms of common ion effect and Le Chatelier's Principle | 5-6 |
| • Correctly calculates two of the solubilities<br>AND<br>• Accounts in detail for differences in solubility for each salt in terms of common ion effect and Le Chatelier's Principle<br>OR<br>• Correctly calculates three solubilities<br>AND<br>• Accounts for differences in general terms (not specific to each salt) | 3-4 |
| • Calculates one or two solubilities correctly and states the cause is the common ion effect<br>OR<br>• Uses Le Chatelier's Principle to describe why the solubility will change | 2 |
| • Some relevant information | 1 |

***Sample Answer:***

$K_{sp}$ ($PbI_2$) = $9.8 \times 10^{-9}$

$PbI_2$ (s) ⇌ $Pb^{2+}$ (aq) + $2I^-$ (aq)
Let solubility = s
Then $9.8 \times 10^{-9} = (s)(2s)^2$
And s = 0.000135 mol $L^{-1}$

In 0.1 M $Pb(NO_3)_2$, $[Pb^{2+}] = 0.1 + s$ Assume $s << 0.1$
Then $9.8 \times 10^{-9} = (0.1)(2s)^2$
And s = 0.000156 mol $L^{-1}$ Note: the assumption is valid

In 0.1 M $MgI_2$ $[Pb^{2+}]$ = s and $[I^-] = 0.2 + 2s$ Assume $2s << 0.2$
Then $9.8 \times 10^{-9} = (s)(0.2+ 2s)^2$
And $s = 2.5 \times 10^{-7}$ mol $L^{-1}$

The solubility is greatest in water and least in $MgI_2$. When the lead iodide is added to the two salt solutions the solubility decreases due to the common ion effect. In lead nitrate the common ion is $Pb^{2+}$, so the equilibrium is shifted to the left, as predicted by Le Chatelier's Principle, to minimise the change: $PbI_2$ (s) ⇌ $Pb^{2+}$ (aq) + $2I^-$ (aq)

In magnesium iodide the common ion is $I^-$ so the equilibrium shifts to the left as well. However, the increase in concentration of iodide ions was two times greater than that for lead ions, so the shift was more pronounced in magnesium iodide solution.

**Question 35** (3 marks)
***Outcomes Assessed: CH12-7, CH12-12***
***Targeted Performance Bands: 3-6***

| Criteria | Marks |
|---|---|
| • Describes the effect on K<br>AND<br>• degree of ionisation using equilibrium theory<br>AND<br>• includes a suitable equation | 3 |
| • Describes the effect on K OR degree of ionisation<br>AND<br>• includes a suitable equation | 2 |
| • One of the above | 1 |

***Sample Answer:***

$K_a$ is given at a specific temperature and only changes if the temperature changes. In this case there is no temperature change, so K remains constant.
$CH_3CH_2COOH\ (aq) + H_2O\ (l) \rightleftharpoons CH_3CH_2COO^-\ (aq) + H_3O^+\ (aq)$
Evaporation removes water, so the system will shift left to replace the water. Consequently, there will be less $CH_3CH_2COO^-\ (aq)$ and $H_3O^+\ (aq)$ and more $CH_3CH_2COOH\ (aq)$ and the degree of ionisation will be reduced.