

- Copyright for test papers and marking guides remains with *West Australian Test Papers*.
- The papers may only be reproduced within the purchasing school according to the advertised conditions of sale.
- Test papers must be withdrawn after use and stored securely in the school until Friday 29th November 2019.



CHEMISTRY

UNITS 1 & 2

2019

MARKING GUIDE

Section One: Multiple-choice

(50 marks)

| | |
|---|--|
| 1 | a <input type="checkbox"/> b <input type="checkbox"/> c <input type="checkbox"/> d <input checked="" type="checkbox"/> |
| 2 | a <input type="checkbox"/> b <input checked="" type="checkbox"/> c <input type="checkbox"/> d <input type="checkbox"/> |
| 3 | a <input type="checkbox"/> b <input type="checkbox"/> c <input checked="" type="checkbox"/> d <input type="checkbox"/> |
| 4 | a <input checked="" type="checkbox"/> b <input type="checkbox"/> c <input type="checkbox"/> d <input type="checkbox"/> |
| 5 | a <input type="checkbox"/> b <input checked="" type="checkbox"/> c <input type="checkbox"/> d <input type="checkbox"/> |

| | |
|----|--|
| 11 | a <input type="checkbox"/> b <input type="checkbox"/> c <input type="checkbox"/> d <input checked="" type="checkbox"/> |
| 12 | a <input checked="" type="checkbox"/> b <input type="checkbox"/> c <input type="checkbox"/> d <input type="checkbox"/> |
| 13 | a <input type="checkbox"/> b <input checked="" type="checkbox"/> c <input type="checkbox"/> d <input type="checkbox"/> |
| 14 | a <input type="checkbox"/> b <input type="checkbox"/> c <input type="checkbox"/> d <input checked="" type="checkbox"/> |
| 15 | a <input type="checkbox"/> b <input type="checkbox"/> c <input checked="" type="checkbox"/> d <input type="checkbox"/> |

| | |
|----|--|
| 21 | a <input type="checkbox"/> b <input type="checkbox"/> c <input type="checkbox"/> d <input checked="" type="checkbox"/> |
| 22 | a <input type="checkbox"/> b <input type="checkbox"/> c <input checked="" type="checkbox"/> d <input type="checkbox"/> |
| 23 | a <input type="checkbox"/> b <input checked="" type="checkbox"/> c <input type="checkbox"/> d <input type="checkbox"/> |
| 24 | a <input type="checkbox"/> b <input checked="" type="checkbox"/> c <input type="checkbox"/> d <input type="checkbox"/> |
| 25 | a <input type="checkbox"/> b <input checked="" type="checkbox"/> c <input type="checkbox"/> d <input type="checkbox"/> |

| | |
|----|--|
| 6 | a <input type="checkbox"/> b <input checked="" type="checkbox"/> c <input type="checkbox"/> d <input type="checkbox"/> |
| 7 | a <input checked="" type="checkbox"/> b <input type="checkbox"/> c <input type="checkbox"/> d <input type="checkbox"/> |
| 8 | a <input type="checkbox"/> b <input type="checkbox"/> c <input type="checkbox"/> d <input checked="" type="checkbox"/> |
| 9 | a <input type="checkbox"/> b <input checked="" type="checkbox"/> c <input type="checkbox"/> d <input type="checkbox"/> |
| 10 | a <input type="checkbox"/> b <input type="checkbox"/> c <input checked="" type="checkbox"/> d <input type="checkbox"/> |

| | |
|----|--|
| 16 | a <input type="checkbox"/> b <input checked="" type="checkbox"/> c <input type="checkbox"/> d <input type="checkbox"/> |
| 17 | a <input type="checkbox"/> b <input type="checkbox"/> c <input type="checkbox"/> d <input checked="" type="checkbox"/> |
| 18 | a <input checked="" type="checkbox"/> b <input type="checkbox"/> c <input type="checkbox"/> d <input type="checkbox"/> |
| 19 | a <input type="checkbox"/> b <input type="checkbox"/> c <input type="checkbox"/> d <input checked="" type="checkbox"/> |
| 20 | a <input type="checkbox"/> b <input type="checkbox"/> c <input checked="" type="checkbox"/> d <input type="checkbox"/> |

(2 marks per question)

Section Two: Short answer**35% (70 marks)**

This section has **8** questions. Answer **all** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time: 60 minutes.

Question 26**(13 marks)**

Consider the solubility data provided in the table below.

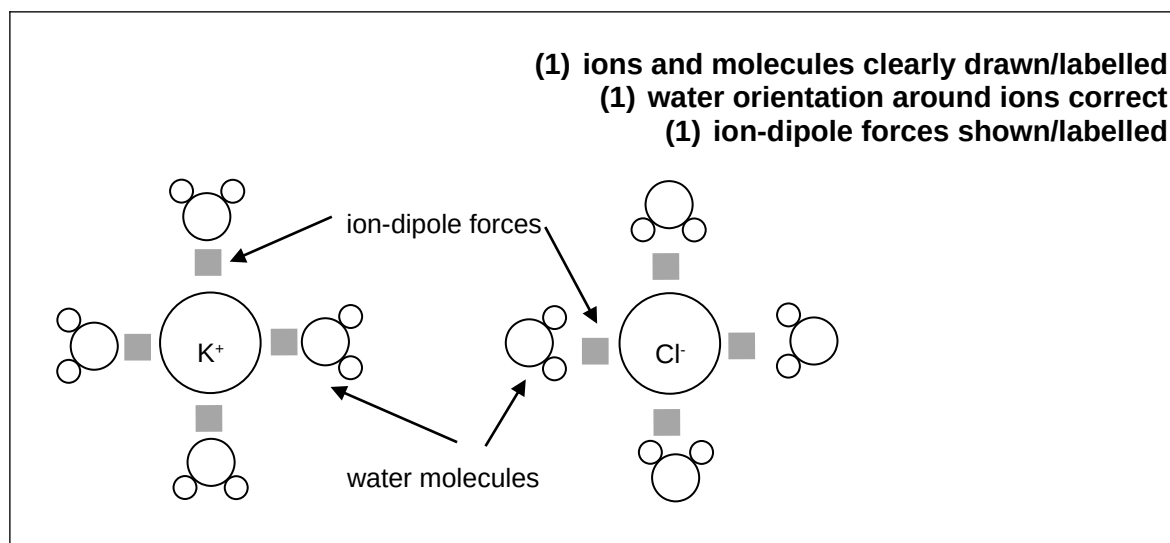
| Substance | Solubility in water at 25 °C |
|-----------------|------------------------------|
| KCl | 254 g L ⁻¹ |
| SO ₂ | 94.0 g L ⁻¹ |
| I ₂ | 0.290 g L ⁻¹ |

- (a) Explain, in terms of intermolecular forces, the differing solubilities of SO₂ and I₂ in water.

(4 marks)

- Iodine is non polar and only contains dispersion forces
- Sulfur dioxide is polar and contains dispersion forces and dipole-dipole forces
- Water is highly polar and contains dispersion forces, dipole-dipole forces and hydrogen bonding
- The type and strength of intermolecular forces within water and sulfur dioxide are more similar, therefore sulfur dioxide will be able to form stronger forces of attraction with water than iodine

- (b) Draw a labelled diagram showing the arrangement of solute and solvent species, and the attractive forces that exist, when KCl has been dissolved in water. (3 marks)



- (c) Using the data in the table, describe how you would produce a saturated solution of KCl, if you were given a 31.75 g sample of KCl(s). (2 marks)

- **Dissolve in 125 mL of water**
- **At 25 °C**

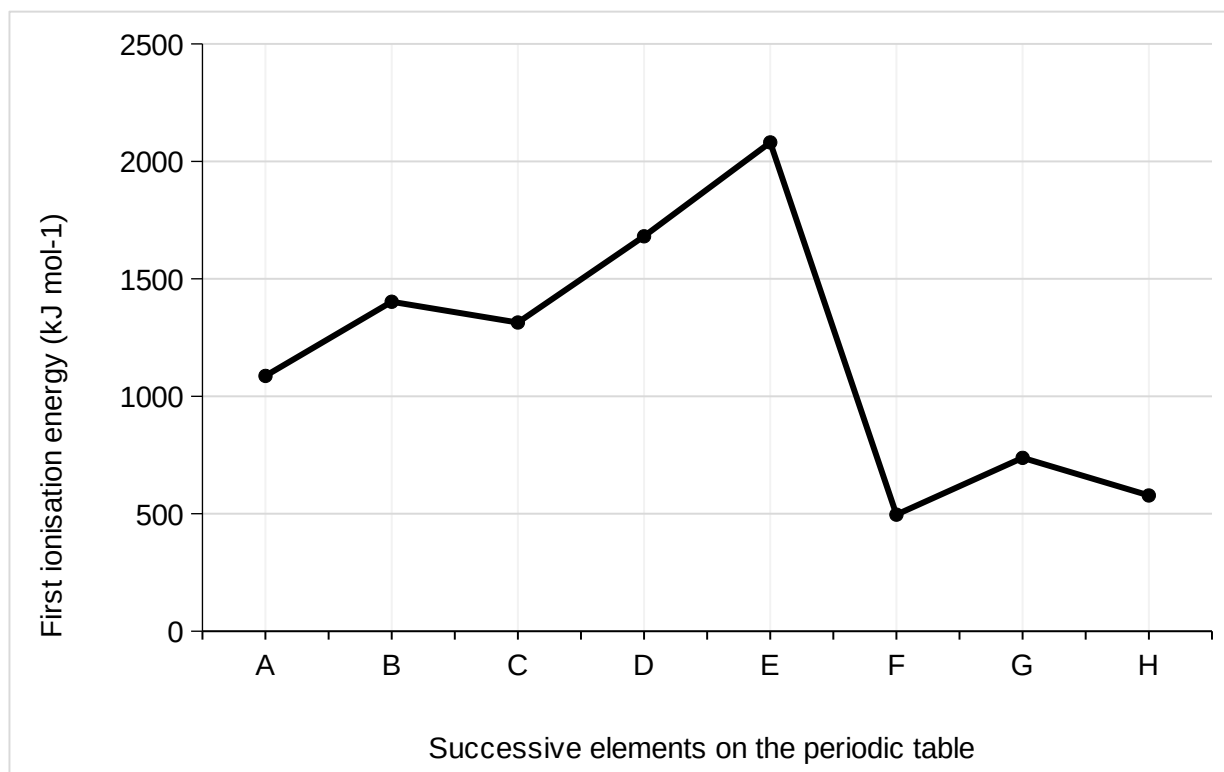
- (d) Calculate the concentration in parts per million, of a saturated solution of KCl at 25 °C. The density of the solution is 1.178 g mL⁻¹. (4 marks)

| | |
|---------|--|
| in 1 L; | $ \begin{aligned} m(\text{KCl}) &= 254 \text{ g} \\ &= 254\,000 \text{ mg} \\ \\ m(\text{solution}) &= V \\ &= 1.178 \times 1000 \\ &= 1178 \text{ g} \\ \\ &= 1.178 \text{ kg} \\ \\ \text{ppm} &= 254\,000 / 1.178 \\ &= 215619.7 \text{ ppm} \\ &= 2.16 \times 10^5 \text{ ppm} \end{aligned} $ |
|---------|--|

Question 27

(7 marks)

The graph below displays data on the first ionisation energy of eight (8) successive elements on the periodic table (labelled as A-H).



(a) Define 'first ionisation energy'. (2 marks)

- **Energy required to remove outermost electron**
- **From one mole of an element in the gaseous state**

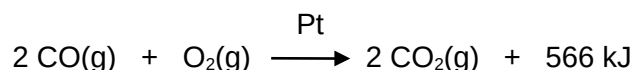
(b) Which element (A-H) (5 marks)

- | | | |
|-------|---|----------|
| (i) | has the smallest atomic radius? | E |
| (ii) | has the highest electronegativity? | D |
| (iii) | is most likely to form covalent network bonds? | A |
| (iv) | is an alkaline-earth metal? | G |
| (v) | is most likely to form an anion with 2- charge? | C |

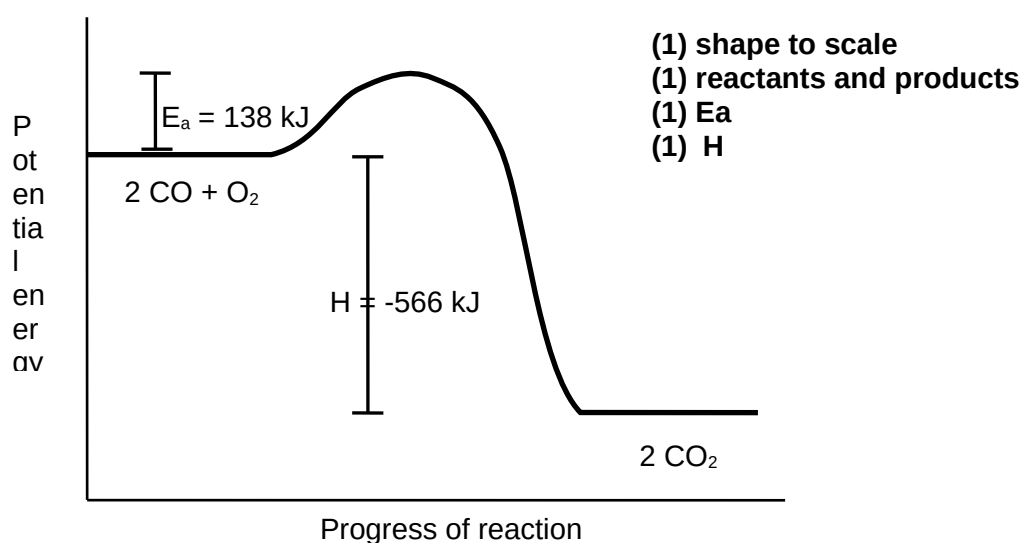
Question 28

(8 marks)

One of the functions of a catalytic converter in a car, is to convert poisonous carbon monoxide gas into non-toxic carbon dioxide. This reaction can be catalysed by single platinum atoms which are attached to a copper(II) oxide support. The activation energy in the presence of these platinum atoms is 138 kJ. The chemical equation for this reaction is given below.



- (a) Draw, to scale, an energy profile diagram for the **catalysed** reaction. Label the activation energy and the heat of reaction. (4 marks)



- (b) State how the value of the activation energy and the heat of reaction would be altered (higher, lower, no change) in the **uncatalysed** reaction. (2 marks)

| | Value (higher / lower / no change) |
|-------------------|---------------------------------------|
| Activation energy | higher |
| Heat of reaction | no change |

Single platinum atoms have a diameter of 0.278 nm.

- (c) Define a 'nanomaterial', and state whether this platinum catalyst qualifies as a nanomaterial. (2 marks)

- **Nanomaterials are materials with particles in the size range 1-100 nm**
- **No, the platinum atoms are too small to be classified as a nanoparticle**

Question 29

(9 marks)

The following graph illustrates Boyle's law, which shows the relationship between the pressure and volume of an ideal gas at constant temperature.

As suggested by the shape of the graph, no matter how high the pressure is increased, the volume of the gas will never become zero.

- (a) Explain why this is so, referring to the difference between 'ideal' and 'real' gases in your answer. (3 marks)
- **Particles of ideal gases are considered to have no volume**
 - **However, particles of a real gas do have volume**
 - **Therefore the volume of a gas would never be zero (under high pressures the gas would condense to form a liquid)**

A sample of methane gas was stored in a chamber at 34 °C and 92 kPa.

- (b) What changes would need to be made to the storage temperature and volume to achieve STP conditions? (circle your answer for each) (2 marks)

Temperature

increase / decrease

Volume

increase / decrease

The final volume of methane gas, once corrected to STP, was 673.5 mL.

- (c) Calculate the number of molecules of methane gas present. State your answer to the correct number of significant figures. (3 marks)

$$\begin{aligned}n(\text{CH}_4) &= V / 22.71 \\&= 0.6735 / 22.71 \\&= 0.0296565 \text{ mol} \\N(\text{CH}_4) &= n \times A_v \\&= 0.0296565 \times 6.022 \times 10^{23} \\&= 1.7859 \times 10^{22} \text{ molecules} \\&= 1.786 \times 10^{22} \text{ molecules (4 SF)}\end{aligned}$$

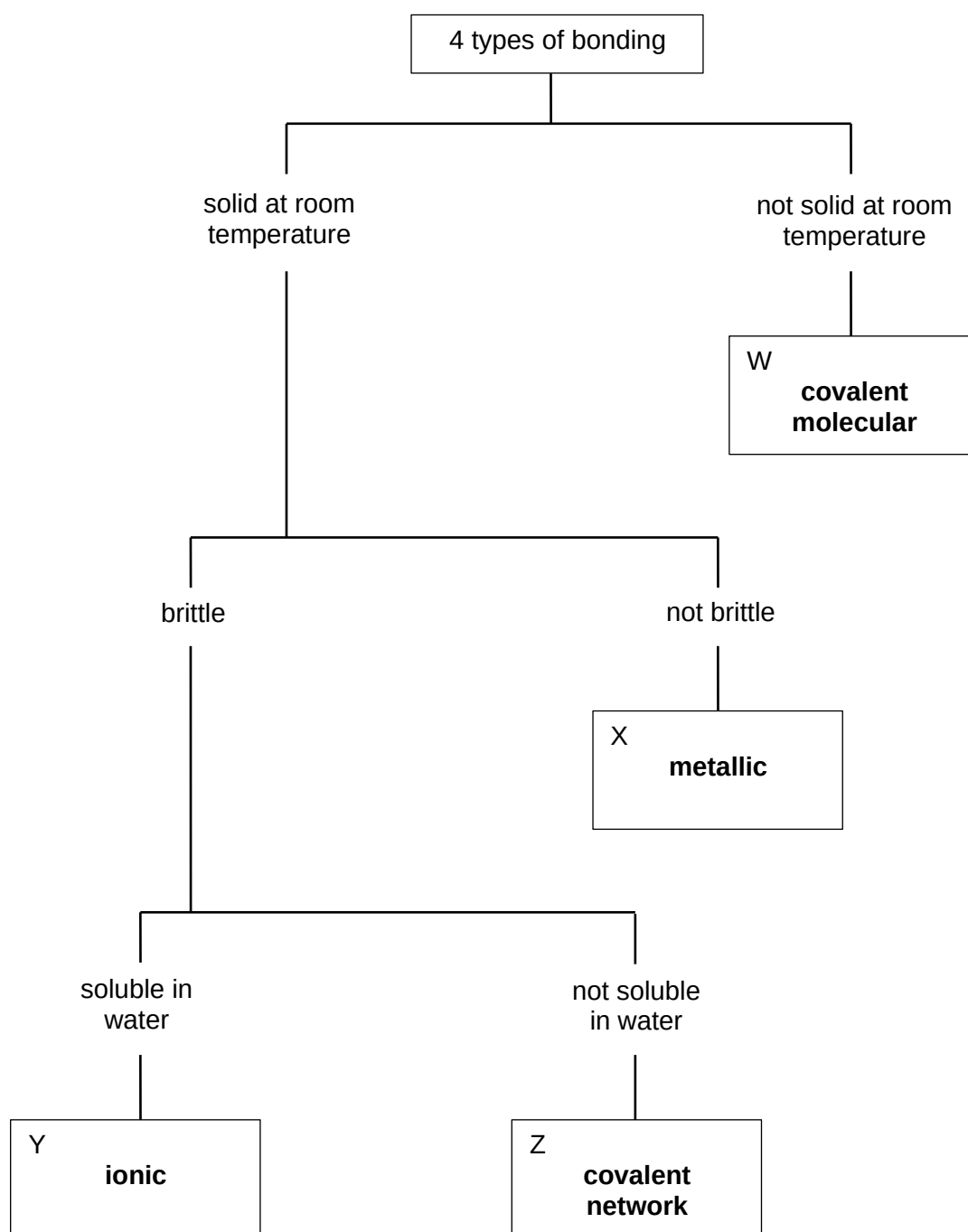
- (d) Calculate the number of hydrogen atoms present in this gas sample. (1 mark)

$$\begin{aligned}N(\text{H}) &= 4 \times N(\text{CH}_4) \\&= 4 \times 1.7859 \times 10^{22} \\&= 7.144 \times 10^{22} \text{ atoms}\end{aligned}$$

Question 30**(8 marks)**

The following question refers to four (4) different substances, each displaying a different type of bonding. One substance is metallic, one is ionic, one is covalent molecular and one is covalent network. You may assume each of the substances show the typical characteristic properties of the four bonding types.

- (a) Complete the following dichotomous key, by writing the name of one type of bonding (metallic, ionic, covalent molecular, covalent network) in each of the boxes labelled W, X, Y and Z. (4 marks)



- (b) Justify the choice of bonding you made for W. (2 marks)
- **covalent molecular substances have weak intermolecular forces**
 - **therefore only a small amount of heat energy is required to disrupt the intermolecular forces, resulting in a low boiling point (therefore most likely to be liquid or gas at room temperature)**
- (c) Justify the choice of bonding you made for X. (2 marks)
- **metals have non-directional bonding OR metals consist of positive metal ions surrounded by a sea of delocalised electrons**
 - **therefore when a force is applied they can distort / change shape without disrupting the bonding (therefore not brittle)**

Question 31**(9 marks)**

Calcium dihydrogenphosphate, $\text{Ca}(\text{H}_2\text{PO}_4)_2$, and ammonium hydrogenphosphate, $(\text{NH}_4)_2\text{HPO}_4$, are both compounds that are commonly found in fertilisers.

- (a) Determine the percentage by mass of phosphorus that could be released into the soil by each compound. (4 marks)

$$\begin{aligned}\% \text{ P in } \text{Ca}(\text{H}_2\text{PO}_4)_2 &= (2 \times 30.97) / 234.052 \times 100 \\ &= 26.46 \%\end{aligned}$$

$$\begin{aligned}\% \text{ P in } (\text{NH}_4)_2\text{HPO}_4 &= 30.97 / 132.062 \times 100 \\ &= 23.45 \%\end{aligned}$$

- (b) Describe how these two white salts could be distinguished using a flame test. Your answer should include an explanation of how an emission spectrum is produced in a flame test. (5 marks)

- calcium ions would produce a red flame test, ammonium ions would not produce a colour change
OR the salts would produce different colours in a flame test due to the different cations present / due to one having a metallic cation
- when a substance is strongly heated, electrons can absorb energy and jump to a higher energy level, becoming excited
- the excited atoms then release this energy (photons) as the electrons move back down to the ground state
- this process produces an emission spectrum
- each element has a characteristic / unique emission spectrum that can be used to identify / distinguish

Question 32

(7 marks)

Cow's milk is a very nutritious substance. However, it tends to sour quickly and have a short shelf life. This is due to the presence of bacteria in milk called *lactobacillus*. These bacteria convert the lactose present in milk into lactic acid. This chemical reaction increases the acidity of the milk, causing it to taste sour and separate into solid curds and liquid whey.

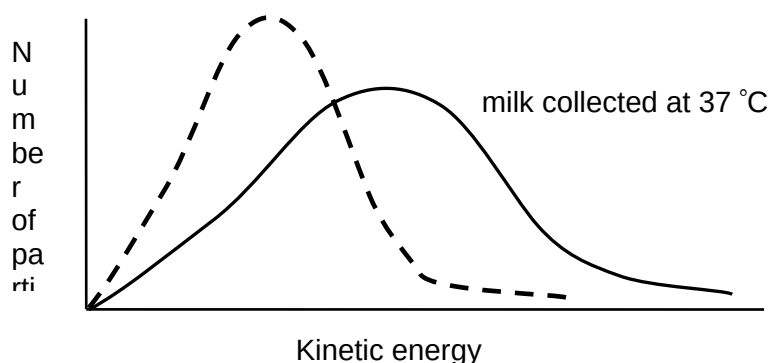
One process used to increase the shelf life of milk is pasteurisation. The process of pasteurisation kills many of the bacteria that convert the lactose to lactic acid.

- (a) Explain, in terms of the collision theory, how the pasteurising process increases the shelf life of milk. (3 marks)

- **decreases the concentration of lactobacillus / bacteria**
- **this decreases the frequency of successful collisions**
- **this decreases the reaction rate (and therefore increases the shelf life)**

Since pasteurisation does not kill all of the bacteria, milk is also cooled and refrigerated at a temperature of around 4 °C to increase its shelf life.

- (b) On the curve below, sketch the effect of refrigeration on the distribution of molecular energies in milk. (1 mark)



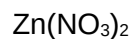
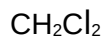
- (c) Explain, in terms of the collision theory, how the refrigeration process increases the shelf life of milk. (3 marks)

- **decreases the average kinetic energy (also decreases frequency of collision)**
- **decreases the proportion of particles that have kinetic energy greater than activation energy**
- **decreases the reaction rate (and therefore increases the shelf life)**

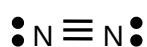
Question 33

(9 marks)

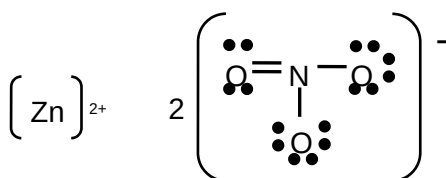
Use the eight (8) substances below to answer the following questions. Each substance **may only be used once**.



- (a) Draw the structural formula for a substance containing no polar bonds. Represent all valence shell electron pairs either as : or –. (1 mark)



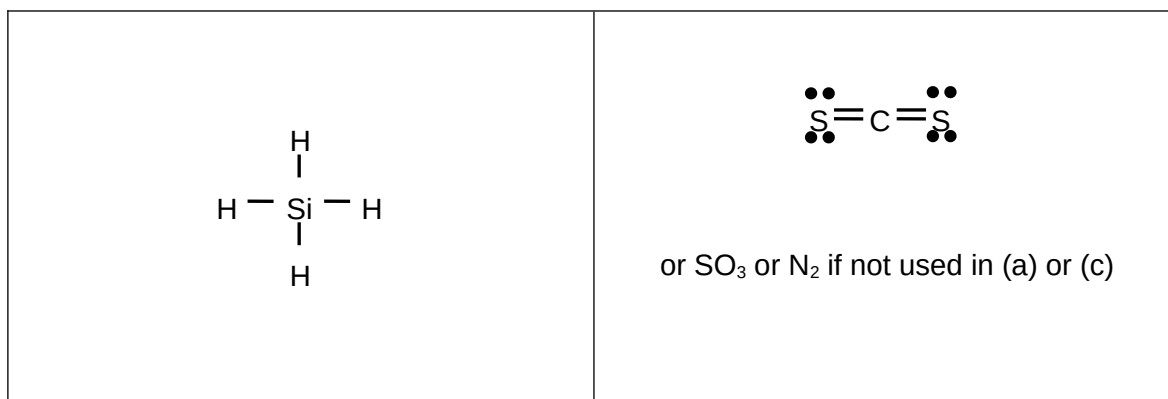
- (b) Draw the structural formula for an ionic substance. Represent all valence shell electron pairs either as : or –. (2 marks)



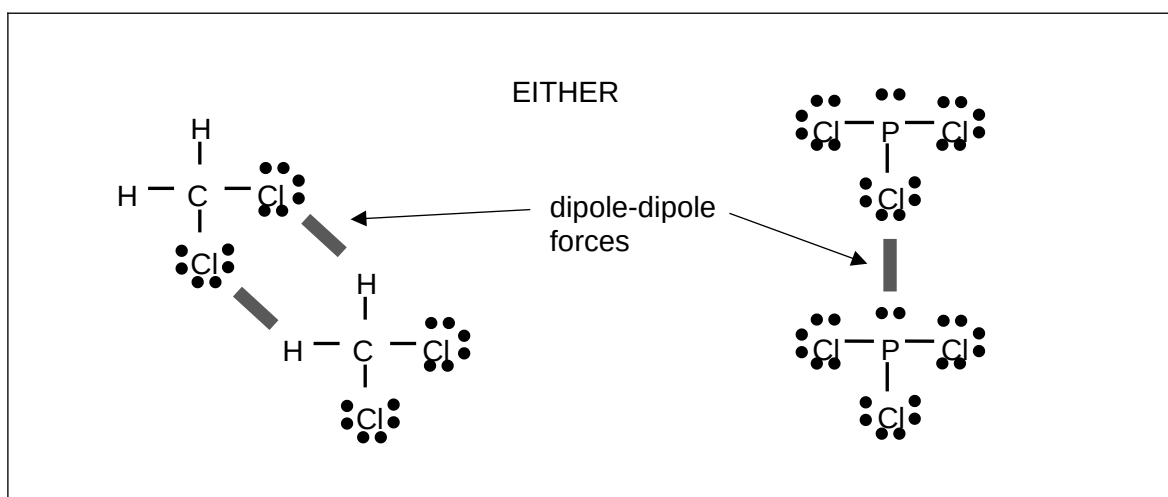
- (c) Draw the structural formula for a substance matching each molecular shape. Represent all valence shell electron pairs either as : or –. (2 marks)

| Triangular planar | V-shaped / Bent |
|---|---|
| $\begin{array}{c} \text{:}\ddot{\text{O}}\text{=S-}\ddot{\text{O}}\text{:} \\ \\ \text{:}\ddot{\text{O}}\text{:} \end{array}$ | $\begin{array}{c} \text{:} \\ \text{H-S:} \\ \\ \text{H} \end{array}$ |

- (d) Draw the structural formulas for two substances that are non-polar. Represent all valence shell electron pairs either as : or –. (2 marks)



- (e) Draw a diagram illustrating dipole-dipole forces between molecules of the same substance. (2 marks)



(1m molecule, 1m dipole-dipole forces)

End of Section Two

Section Three: Extended answer**40% (80 marks)**

This section contains **five (5)** questions. You must answer **all** questions. Write your answers in the spaces provided below.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression. Lists or dot points are unlikely to gain full marks.

Final answers to calculations should be expressed to the appropriate number of significant figures.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time: 70 minutes.

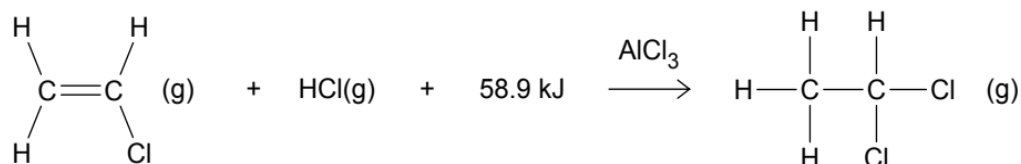
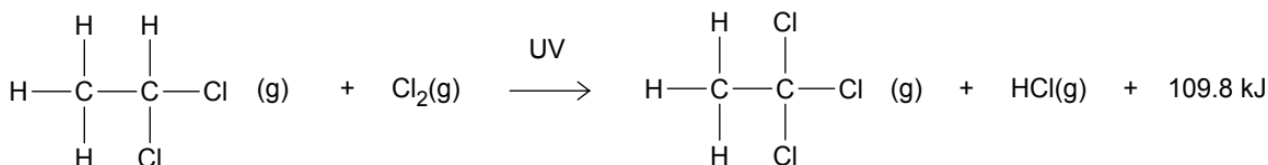
Question 34**(16 marks)**

The colourless liquid 1,1,1-trichloroethane was once widely manufactured and used as an aerosol propellant, a cleaning agent for circuit boards and an organic solvent for inks, paints and adhesives. However, it has been banned since 1996 because it was found to be one of the group of compounds contributing to the formation of the 'hole in the ozone layer'.

Industrially 1,1,1-trichloroethane was produced in two steps. Step 1 involves the reaction of chloroethene with hydrogen chloride to produce 1,1-dichloroethane. This reaction is catalysed by aluminium chloride or iron(III) chloride.

In Step 2, the 1,1-dichloroethane reacts with chlorine in the presence of UV radiation to produce 1,1,1-trichloroethane. This step also forms hydrogen chloride, which is recycled for use in Step 1.

The chemical equations for the production of 1,1,1-trichloroethane are given below.

Step 1Step 2

- (a) Name the type of reactions occurring in Step 1 and Step 2. Briefly explain the difference between these reaction types. (4 marks)

Step 1 reaction: **addition (hydrohalogenation)**

Step 2 reaction: **substitution**

- **Addition reactions are when a double C=C bond is broken and a molecule is incorporated into the organic structure across the double bond**
- **Substitution reactions are when hydrogen atoms are replaced by another atom, for example a halogen**

The reaction in Step 2 also produces a small quantity of a second organic product. This unwanted product is separated from the 1,1,1-trichloroethane by distillation.

- (b) Draw a structural diagram (i.e. showing all bonds) and give the IUPAC name for this unwanted organic product. (2 marks)

| Structural diagram | IUPAC name |
|--|------------------------------|
| <pre> H H H — C — C — Cl Cl Cl</pre> | 1,1,2-trichloroethane |

- (c) Describe how the process of distillation can be used to separate a mixture. (3 marks)

- **Distillation separates the components of a mixture based on differing boiling points**
- **The mixture is heated and the various components vapourise at different temperatures**
- **The vapours are condensed and the different components are collected**

If 976 g of 1,1,1-trichloroethane is produced;

- (d) Calculate the volume of chloroethene, stored at STP, that would be required for this process. (You may ignore the formation of unwanted organic products and assume both reactions are 100% efficient.) (3 marks)

$$\begin{aligned} n(\text{CH}_3\text{CCl}_3) &= m/M \\ &= 976 / 133.394 \\ &= 7.31667 \text{ mol} \end{aligned}$$

$$\begin{aligned} n(\text{CH}_2\text{CHCl required}) &= n(\text{CH}_3\text{CCl}_3) \\ &= 7.31667 \text{ mol} \end{aligned}$$

$$\begin{aligned} V(\text{CH}_2\text{CHCl}) &= 22.71 \times n \\ &= 22.71 \times 7.31667 \\ &= 166.162 \text{ L} \\ &= 166 \text{ L (3 SF)} \end{aligned}$$

- (e) Classify the overall two-step production process as endothermic or exothermic. Justify your answer. (2 marks)

- **Exothermic**
- **More energy is released in Step 2 than is absorbed in Step 1**
(OR $-109.8 + 58.9 = -50.9$ kJ, therefore 50.9 kJ of energy is released)

- (f) Calculate the quantity of energy released, or absorbed, if this mass of 1,1,1-trichloroethane is produced. (2 marks)

50.9 kJ energy released per mole of 1,1,1-trichloroethane

$$\begin{aligned} \text{Energy} &= H \times n \\ &= 50.9 \times 7.31667 \\ &= 372.418 \text{ kJ} \\ &= 372 \text{ kJ (3 SF)} \end{aligned}$$

Question 35**(22 marks)**

Earth is sometimes referred to as a 'Goldilocks' planet. This is because the average global surface temperature of 15 °C is not too hot, nor too cold, but "just right" for water to exist as a liquid.

The table below provides data regarding two substances of similar molecular mass; water and methane.

| | M | Melting point (°C) | Boiling point (°C) |
|----------------------------|--------|--------------------|--------------------|
| Water (H ₂ O) | 18.016 | 0 | 100 |
| Methane (CH ₄) | 16.042 | -182 | -162 |

(a) Explain why the dispersion forces in water and methane are of similar strength. (2 marks)

- **Similar M indicates a similar number of electrons.**
- **Dispersion forces occur due to the formation of temporary dipoles as a result of random electron motion.**

(b) Explain why the boiling point of water and methane differ so greatly. (4 marks)

- **Water is polar and exhibits dispersion forces, dipole-dipole forces and hydrogen bonding.**
- **Methane is non-polar and only exhibits dispersion forces.**
- **Therefore the sum of intermolecular forces in water are much stronger.**
- **This requires a greater amount of heat energy to disrupt the intermolecular forces and therefore the boiling point of water is higher.**

An interesting and rare property of water is that it is less dense in the solid state than in the liquid state.

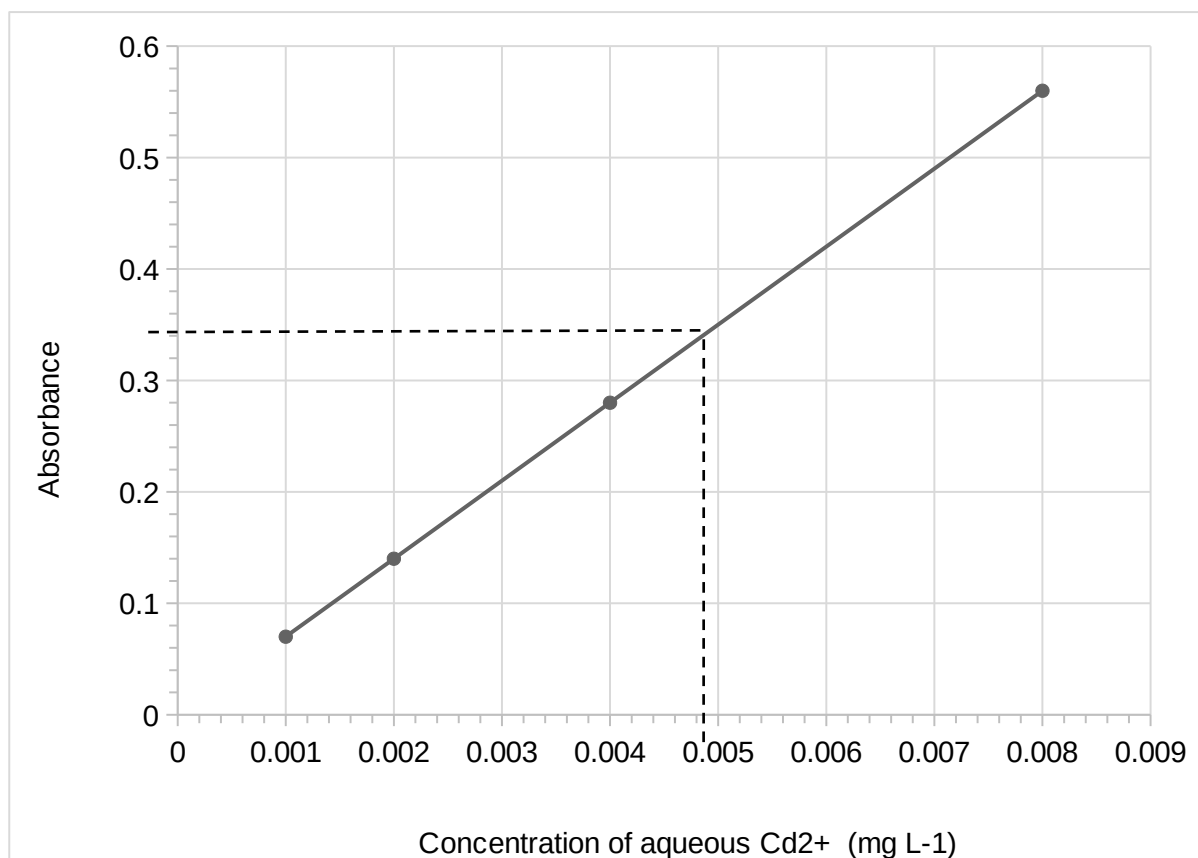
(c) Explain why ice is less dense than water. (2 marks)

- **When water freezes, a rigid / crystalline lattice structure is formed, held together by hydrogen bonds.**
- **To form this structure, the water molecules push apart from each other, causing it to be less dense.**

Potable (drinking) water is subject to regular analysis to monitor its quality. One of the factors assessed in potable water, is the presence of heavy metal contaminants such as arsenic, cadmium, chromium, lead and mercury.

Cadmium can be found in water in the form of $\text{Cd}^{2+}(\text{aq})$ ions. It is a toxic substance that can cause damage to the kidneys, liver, lungs and central nervous system. The maximum amount of $\text{Cd}^{2+}(\text{aq})$ allowed in potable water, as set by the U.S. Environmental Protection Agency, is 0.005 mg L^{-1} .

Analysis for $\text{Cd}^{2+}(\text{aq})$ is routinely performed by atomic absorption spectroscopy (AAS), due to its ability to detect extremely low concentrations of metals. The AAS calibration curve for $\text{Cd}^{2+}(\text{aq})$ is shown below.



Samples of water were taken from three different locations around a mine site and analysed by AAS for the presence of $\text{Cd}^{2+}(\text{aq})$. The results of the analysis are provided in the table.

| Sample | Absorbance |
|--------|------------|
| X | 0.33 |
| Y | 0.40 |
| Z | 0.21 |

(d) Do any of the water samples (X, Y, Z) contain $\text{Cd}^{2+}(\text{aq})$ at a level too high for human consumption? Justify your answer using the graph provided. (3 marks)

- **Yes, sample Y**
- **Any absorbance greater than 0.35 corresponds to a Cd^{2+} concentration higher than the allowed 0.005 mg L^{-1}**
- **(working shown on calibration curve, see previous page)**

The $\text{Cd}^{2+}(\text{aq})$ from a highly contaminated sample of water was to be removed by precipitation. The analysis by AAS determined the concentration of $\text{Cd}^{2+}(\text{aq})$ in the water to be 0.0723 mg L^{-1} .

(e) Calculate the concentration of $\text{Cd}^{2+}(\text{aq})$ in moles per litre (mol L^{-1}). (2 marks)

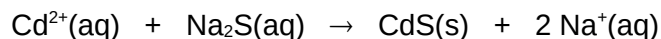
in 1 L;

$$\begin{aligned}
 m(\text{Cd}^{2+}) &= 0.0723 \times 10^{-3} \\
 &= 0.0000723 \text{ g} \\
 \text{i.e.} &7.23 \times 10^{-5} \text{ g per litre}
 \end{aligned}$$

$$\begin{aligned}
 n(\text{Cd}^{2+}) &= m/M \\
 &= 0.0000723 / 112.4 \\
 &= 6.4323 \times 10^{-7} \text{ mol} \\
 \text{i.e.} &6.43 \times 10^{-7} \text{ mol per litre}
 \end{aligned}$$

A water tank, holding 35 kL of this contaminated water (containing 0.0723 mg L^{-1} of Cd^{2+}), was treated with **excess** sodium sulfide to precipitate out **all** the cadmium ions. A 2.0 L sample of $0.0125 \text{ mol L}^{-1}$ sodium sulfide was added to the tank. The water in the tank was mixed and left until the reaction was complete.

The chemical equation for the reaction that took place is given below.



- (f) Calculate the mass of $\text{CdS}(\text{s})$ that would precipitate in the tank. (4 marks)

$$\begin{aligned} n(\text{Cd}^{2+}) &= cV \\ &= 6.4323 \times 10^{-7} \times 35\,000 && \text{(1m for kL to L conversion)} \\ &= 0.0225133 \text{ mol} \\ n(\text{CdS}) &= 0.0225133 \text{ mol} \\ m(\text{CdS}) &= nM \\ &= 0.0225133 \times 144.47 \\ &= 3.2525 \text{ g} \\ &= 3.3 \text{ g} \quad (2 \text{ SF}) \end{aligned}$$

- (g) Calculate the final concentration of $\text{Na}^+(\text{aq})$ and $\text{S}^{2-}(\text{aq})$ in the tank. (5 marks)

$$\begin{aligned} n(\text{Na}_2\text{S}) &= cV \\ &= 0.0125 \times 2 \\ &= 0.025 \text{ mol} \\ n(\text{Na}^+) &= 2 \times n(\text{Na}_2\text{S}) \\ &= 0.05 \text{ mol} \\ c(\text{Na}^+) &= n / V \\ &= 0.05 / 35002 \\ &= 1.428 \times 10^{-6} \text{ mol L}^{-1} \\ &= 1.4 \times 10^{-6} \text{ mol L}^{-1} \quad (2 \text{ SF}) \\ n(\text{S}^{2-}) &= n(\text{Na}_2\text{S}) - n(\text{CdS}) \\ &= 0.025 - 0.0225133 \\ &= 0.0024864 \text{ mol} \\ c(\text{S}^{2-}) &= n / V \\ &= 0.0024864 / 35002 \\ &= 7.104 \times 10^{-8} \text{ mol L}^{-1} \\ &= 7.1 \times 10^{-8} \text{ mol L}^{-1} \quad (2 \text{ SF}) \end{aligned}$$

* If students use 35000 L for part (g) final answers will still be the same – allocate max of 4m

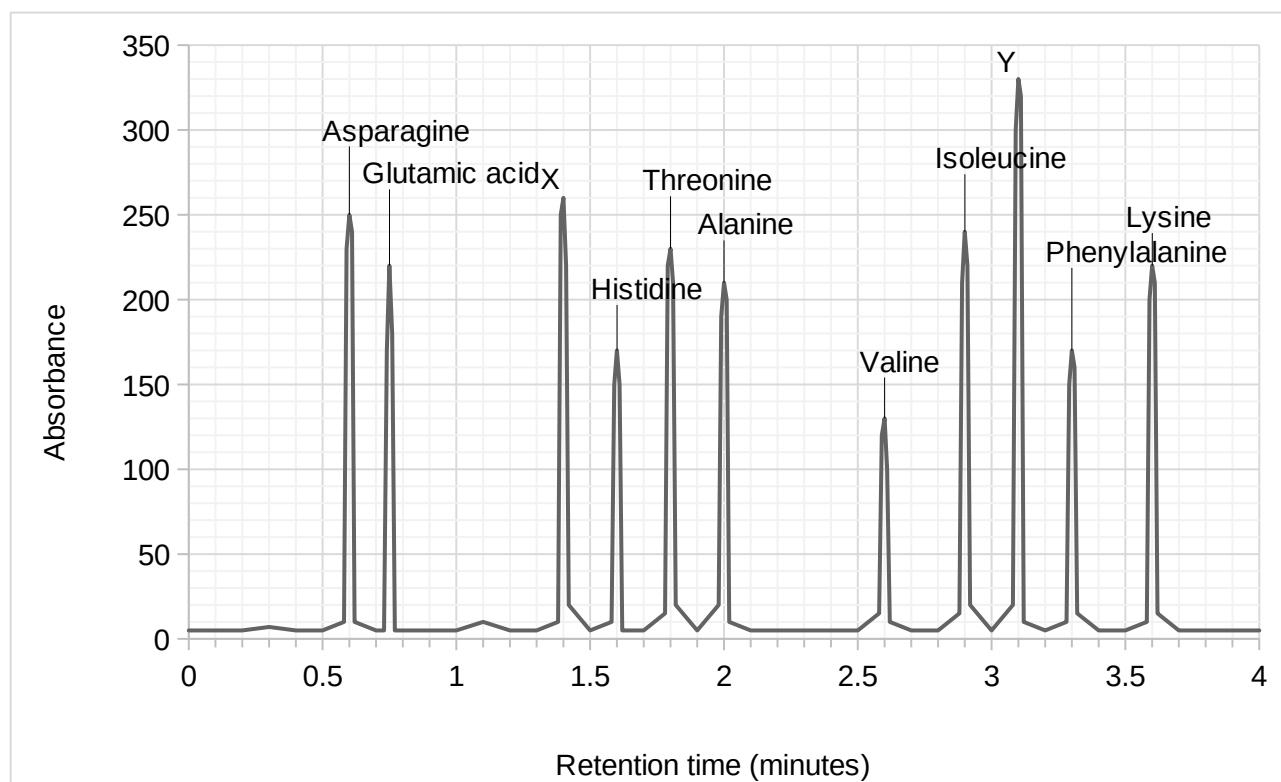
Question 36**(11 marks)**

High performance liquid chromatography (HPLC) can be used to test for the presence of different amino acids in food. This is generally done using 'reverse-phase HPLC' which uses a non-polar stationary phase in combination with a polar mobile phase.

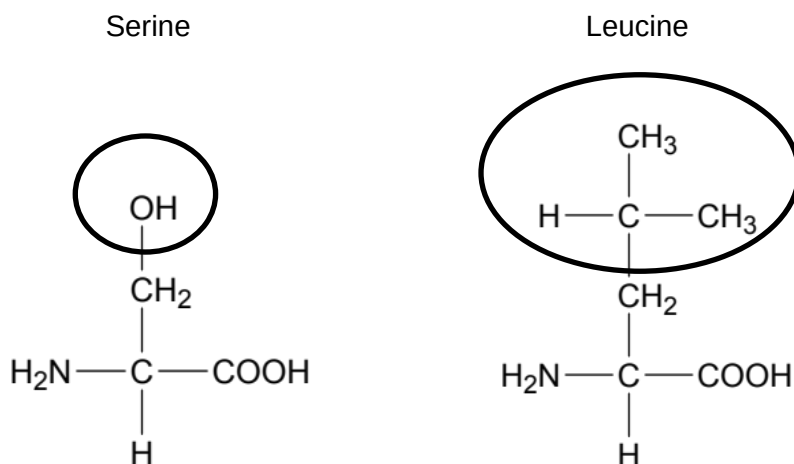
- (a) Explain how reverse-phase HPLC is able to separate the components of a substance. Your answer should refer to the role of both the stationary and mobile phases and the effect of component polarity on retention / elution time. (5 marks)

- Separation of components depends on their interactions with both the stationary and mobile phases.
- Components will move through the column at different speeds according to their polarity.
- Polar components will be more soluble in the mobile phase.
- Non-polar components will adhere more strongly to the stationary phase.
- Polar components will therefore elute fastest and non-polar components slowest.

The chromatogram below was obtained from a reverse-phase HPLC analysis. This particular analysis identifies the presence of 11 different amino acids.



Two peaks on the chromatogram have been labelled X and Y. These correspond to the amino acids serine and leucine. Structural diagrams of serine and leucine are shown below.



- (b) On the diagrams above, circle the sections where the amino acid molecules differ structurally from one another. (1 mark)
- (c) Considering the circled sections, predict which amino acid corresponds to X and Y on the chromatogram. Briefly justify your answer. (3 marks)

X is: **serine**

(1m for stating both X and Y correctly)

Y is: **leucine**

- **Serine has an additional polar -OH group and so will elute first.**
- **Leucine has a non-polar hydrocarbon group and will move through the column more slowly.**

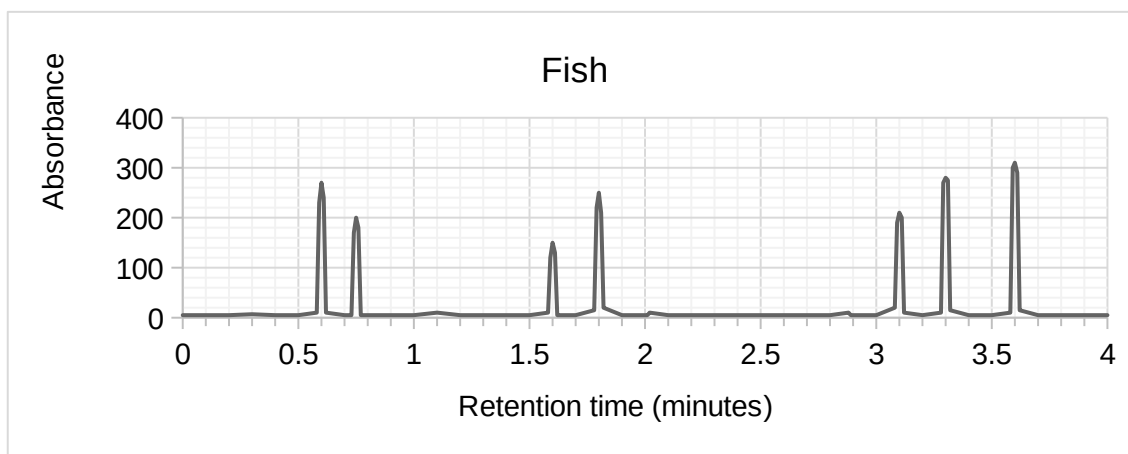
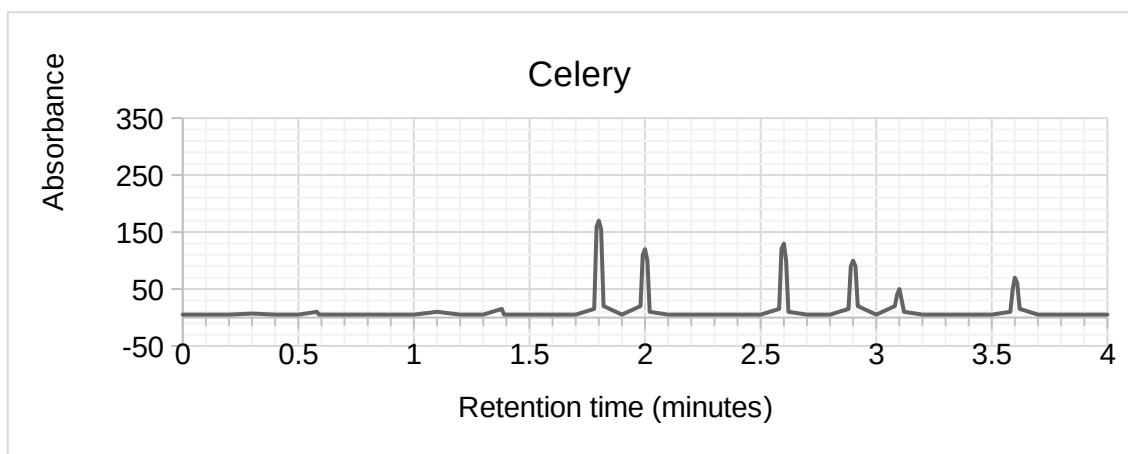
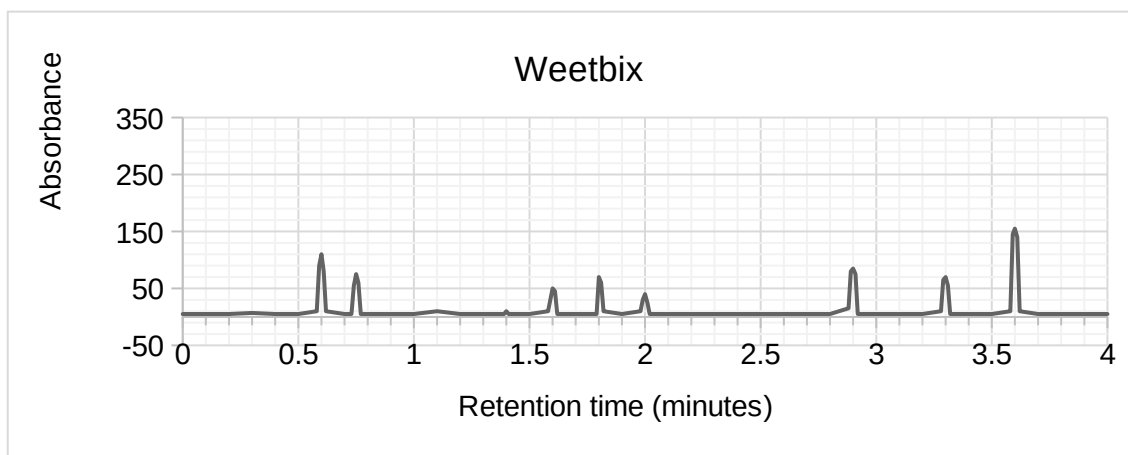
People who have phenylketonuria (PKU) are born with a genetic condition where they are unable to metabolise the amino acid phenylalanine.

When people with PKU consume foods containing phenylalanine, levels of this amino acid can build up in their blood. Without treatment, the disorder can cause intellectual disability and seizures.

All babies born in Australia are screened for PKU at birth, and a strict diet low in phenylalanine is introduced. In this way, the effects of the disorder can be avoided.

Three different foods - Weetbix, celery and fish - were analysed for their amino acid composition. The reverse-phase HPLC analysis was performed under the same conditions as the chromatogram on page 32.

The results of the analyses are shown in the chromatograms below.



- (d) If you were making a recommendation to someone who had PKU about which of these three foods to consume, select which food would be; (2 marks)

least suitable: **fish**

safest to consume: **celery**

Question 37**(15 marks)**

A chemistry teacher gave her class four separate solutions labelled A, B, C and D. The identities of the solutions were;

- 0.15 mol L⁻¹ HNO₃(aq)
- 0.15 mol L⁻¹ K₂CO₃(aq)
- 0.15 mol L⁻¹ Ba(OH)₂(aq)
- 0.15 mol L⁻¹ NH₄Cl(aq)

She then asked the students to design and perform an investigation that would correctly identify A, B, C and D.

The students decided to mix a small amount of each solution with each of the other three solutions. They drew up a table and recorded their results. The initial data they collected is shown below.

| | A | B | C | D |
|---|---|--------------------------|-------------------------|-------------------------|
| A | | white precipitate formed | no change observed | colourless gas produced |
| B | | | colourless gas produced | no change observed |
| C | | | | no change observed |
| D | | | | |

- (a) Which two solutions must have been mixed to produce the white precipitate (i.e. A + B)? (2 marks)
- K₂CO₃
 - Ba(OH)₂

Two different solution combinations (A + D and B + C) produced colourless gases.

- (b) Write balanced chemical equations showing how each of these gases was produced. (4 marks)

| | |
|---|--|
| 1 | $2 \text{HNO}_3(\text{aq}) + \text{K}_2\text{CO}_3(\text{aq}) \rightarrow 2 \text{KNO}_3(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$ <p style="text-align: center;">OR</p> $2 \text{H}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$ |
| 2 | $\text{Ba}(\text{OH})_2(\text{aq}) + 2 \text{NH}_4\text{Cl}(\text{aq}) \rightarrow \text{BaCl}_2(\text{aq}) + 2 \text{NH}_3(\text{g}) + 2 \text{H}_2\text{O}(\text{l})$ <p style="text-align: center;">OR</p> $\text{OH}^-(\text{aq}) + \text{NH}_4^+(\text{aq}) \rightarrow \text{NH}_3(\text{g}) + \text{H}_2\text{O}(\text{l})$ |

The students collected these two colourless gases and bubbled them into separate test tubes containing water. They then dropped two pieces of litmus paper, one red and one blue, into each of these test tubes.

Their resultant observations were that both pieces of litmus paper in one test tube were blue, and both pieces of litmus paper in the other test tube were red.

- (c) Write balanced chemical equations, showing how the reaction of each gas with water supports these observations. (3 marks)

| | |
|-----------------------------|--|
| Blue litmus (1 equation) | $\text{NH}_3(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$ |
| Red litmus (2 equations) | $\text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{CO}_3(\text{aq})$ $\text{H}_2\text{CO}_3(\text{aq}) \rightarrow \text{H}^+(\text{aq}) + \text{HCO}_3^-(\text{aq})$ |

- (d) Define 'acids' and 'bases' according to the Arrhenius theory. (2 marks)

- **Acids produce $\text{H}^+(\text{aq})$ in aqueous solution.**
- **Bases produce $\text{OH}^-(\text{aq})$ in aqueous solution.**

One group of students had noted an additional observation which they shared with the class.

"The gas produced from the reaction between A + D had a pungent odour."

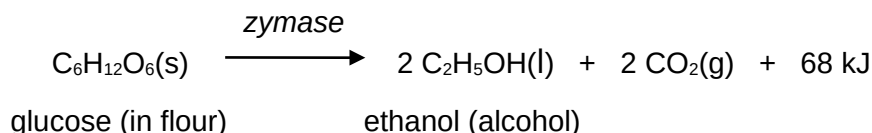
- (e) Identify each of the four original solutions. (4 marks)

| | |
|---|--------------------------|
| A | $\text{Ba}(\text{OH})_2$ |
| B | K_2CO_3 |
| C | HNO_3 |
| D | NH_4Cl |

Question 38**(16 marks)**

Yeast is used in breadmaking to help the dough 'rise'. The rising of the bread dough is a result of the enzyme *zymase* which is present in yeast. This enzyme assists in converting the starch and sugars in the flour into alcohol and carbon dioxide gas. The carbon dioxide gas becomes trapped inside the bread dough in bubbles and causes the dough to expand in size or 'rise'.

The chemical equation for this process is given below.



When bread dough is made, the ingredients are all mixed together, before the dough is kneaded. After kneading, the dough is left to rise, typically until it has 'doubled in size'. During this first rise, heat builds up inside the dough.

The dough is then kneaded again, which evens out the hot spots as well as the build-up of alcohol and carbon dioxide pockets. This second kneading also helps to break up any clusters of yeast.

The dough is then left to rise, once again, until it has doubled in size. After this, the dough is placed in an oven to bake.

(a) What is an enzyme? Explain the function of an enzyme in terms of the collision theory.

(4 marks)

- **Enzymes are biological catalysts.**
- **They increase the reaction rate.**

- **Provide alternate reaction pathway with a lower E_a .**
- **This increases the proportion of particles with kinetic energy greater than E_a .**
- OR**
- **Enzymes must collide with a specific minimum amount of energy with substrates at the active site.**
- **This forms an enzyme-substrate complex which then results in the formation and release of the products.**

(b) In terms of bond breaking and making, explain where the build-up of heat in the dough comes from during the first rise.

(3 marks)

- **The energy required to break the bonds in the reactants is less.**
- **Than the energy released when making the new bonds within the products.**
- **Therefore the reaction is exothermic, producing heat.**

- (c) In terms of the collision theory, explain the benefit of breaking up any clusters of yeast during the second kneading. (3 marks)

- **Increases the surface area of the yeast.**
- **Increases the frequency of collisions.**
- **Increases the reaction rate / rising of the dough.**

A batch of bread dough was made, using 500 g of flour. Once all the ingredients had been mixed and kneaded, the initial volume of the dough was 850 mL. If carbon dioxide is produced at an average rate of 7.81 mL per minute;

- (d) How long should it take before the dough has doubled in size? (1 mark)

$$\begin{aligned} t &= 850 / 7.81 = 108.8 \text{ mins} \\ &= 109 \text{ mins} \end{aligned}$$

The dough was left to rise twice, each time doubling in size due to the carbon dioxide gas that was produced by the fermentation reaction.

- (e) Calculate the percent by mass of flour that would have fermented before the dough was placed in the oven to bake. Assume STP conditions. (5 marks)

$$\begin{aligned} V(\text{CO}_2) &= 850 \text{ mL} \times 2 \text{ rises} \\ &= 1700 \text{ mL} \\ &= 1.7 \text{ L} \end{aligned}$$

$$\begin{aligned} n(\text{CO}_2) &= V / 22.71 \\ &= 1.7 / 22.71 \\ &= 0.0748569 \text{ mol} \end{aligned}$$

$$\begin{aligned} n(\text{glucose}) &= \frac{1}{2} n(\text{CO}_2) \\ &= 0.0374284 \text{ mol} \end{aligned}$$

$$\begin{aligned} m(\text{glucose}) &= nM \\ &= 0.0374284 \times 180.156 \\ &= 6.74296 \text{ g} \end{aligned}$$

$$\begin{aligned} \% \text{ of flour} &= 6.74296 / 500 \times 100 \\ &= 1.34859 \% \\ &= 1.35 \% \quad (3 \text{ SF}) \end{aligned}$$

End of questions