

**CHEMISTRY**  
**Stage 3**

Please place your student identification label in this box

Student Number: In figures

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In words

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**Time allowed for this paper**

Reading time before commencing work: ten minutes

Working time for paper: three hours

**Materials required/recommended for this paper**

***To be provided by the supervisor***

This Question/Answer Booklet

Multiple-choice Answer Sheet

Chemistry Data Sheet

***To be provided by the candidate***

Standard items: pens, pencils, eraser, correction fluid, ruler, highlighters

Special items: non-programmable calculators satisfying the conditions set out by the Curriculum Council for this course

**Important note to candidates**

No other items may be taken into the examination room. It is your responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor before reading any further.

## Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Multiple-choice	25	25	50	25	25
Section Two: Short answer	12	12	60	70	35
Section Three: Extended answer	6	6	70	80	40
					100

## Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2010*. Sitting this examination implies that you agree to abide by these rules.
2. Answer the questions according to the following instructions.

Section One: Answer all questions on the separate Multiple-choice Answer Sheet provided. For each question shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square, do not erase or use correction fluid, and shade your new answer. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Sections Two and Three: Write answers in this Question/Answer Booklet.

3. When calculating numerical answers, show your working or reasoning clearly unless instructed otherwise.
4. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.
5. 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.

**Section One: Multiple-choice****25% (25 Marks)**

This section has **25** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square, do not erase or use correction fluid, and shade your new answer. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time for this section is 50 minutes.

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- Which one of the following solids has the highest conductivity?
  - ice
  - graphite
  - sodium sulfate
  - silicon dioxide
  
- Eight consecutive elements on the Periodic Table have the following first ionisation energies ( $\text{kJ mol}^{-1}$ ):  
707   833   870   1010   1170   376   502   540  
One of these elements is a noble gas. Which one of the following values represents the first ionisation energy of a noble gas?
  - 1170
  - 1010
  - 707
  - 376
  
- The species  ${}^{71}_{33}\text{Ga}^{3+}$  contains
  - 71 protons, 33 neutrons and 68 electrons
  - 33 protons, 38 neutrons and 30 electrons
  - 33 protons, 38 neutrons and 33 electrons
  - 38 protons, 33 neutrons and 35 electrons
  
- An element, X, is in one of the first three rows of the Periodic Table, is a solid at room temperature and forms a basic oxide. Which one of the following is the element most likely to be?
  - a metal
  - a member of group 17
  - carbon
  - sulfur

5. Which one of the following best explains why sodium chloride is almost insoluble in ethanol?
- (a) Sodium and chloride ions do not form strong enough interactions with ethanol to disrupt the sodium chloride crystal lattice and break the van der Waals forces in ethanol.
  - (b) Ethanol cannot interact with sodium ions and chloride ions and so sodium chloride will not dissolve.
  - (c) Although sodium chloride and ethanol are polar they are not similar enough for the 'like dissolves like' rule to apply.
  - (d) Ethanol has strong hydrogen bonds between its molecules and tends to retain its molecular network.
6. In which one of the following pairs of substances will hydrogen bonding between the substances NOT occur?
- (a) HF and  $\text{CH}_3\text{CH}_2\text{COCH}_3$
  - (b)  $\text{CH}_3\text{NH}_2$  and  $\text{CH}_3\text{CHOHCH}_3$
  - (c)  $\text{CH}_3\text{COOH}$  and  $\text{CH}_3\text{COCH}_3$
  - (d)  $\text{CH}_3\text{CH}_3$  and  $\text{CH}_3\text{CH}_2\text{OH}$
7. Which one of the following statements best describes the effect of an addition of a catalyst on a chemical reaction?
- (a) The activation energy is increased and the equilibrium changes rapidly to favour the formation of products.
  - (b) The rate of reaction and equilibrium position both change.
  - (c) The rates of the forward and reverse reaction both increase.
  - (d) The forward reaction rate is increased but there is no change to the reverse rate of reaction.
8. A student attempting to standardise an oxalic acid solution by titration of 20.00 mL aliquots against standard potassium permanganate solution experienced difficulty in obtaining consistent values for the volume of titrant added. Which one of the following sequential steps could be responsible for this lack of precision?
- (a) The burette was cleaned and rinsed thoroughly with standard potassium permanganate solution before being filled.
  - (b) Several 250 mL conical flasks were washed and rinsed thoroughly with oxalic acid solution.
  - (c) A clean pipette was rinsed with the oxalic acid solution and a 20.00 mL aliquot was carefully pipetted into each conical flask.
  - (d) Approximately 20 mL of sulfuric acid was added from a measuring cylinder to each flask before they were heated to approximately 60°C.

9. Which one of the following statements is true?
- (a) The pH of a  $0.100 \text{ mol L}^{-1}$  solution of a strong acid is the same as a  $0.100 \text{ mol L}^{-1}$  solution of a weak acid.
  - (b) Weak acids and weak bases do not react with each other.
  - (c) It is not possible for water to act as an acid and a base.
  - (d) When an acid and a base react, the products consist of a new acid and a new base.
10. A dilute solution of ammonia was titrated with dilute hydrochloric acid. If the indicator used was phenolphthalein, which one of the following statements is true?
- (a) The end-point occurs before the equivalence point.
  - (b) The end-point occurs at the equivalence point.
  - (c) The end-point occurs after the equivalence point.
  - (d) There is no equivalence point because it is the wrong indicator.
11. In the standardization of a hydrochloric acid solution, a student accidentally used some partially hydrated sodium carbonate, instead of the anhydrous salt. As a result, the calculated concentration of HCl would
- (a) equal the actual concentration, as the extra water would have no effect on the reaction.
  - (b) Appear greater than the actual concentration.,
  - (c) Appear less than the actual concentration.
  - (d) Appear greater, or less, than the actual concentration depending on the degree of hydration.
12. Which one of the following equations represents a disproportionation reaction?
- (a)  $\text{Pb}^{2+}(\text{aq}) + 2\text{I}^{-}(\text{aq}) \rightarrow \text{PbI}_2(\text{s})$
  - (b)  $4\text{Fe}(\text{s}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{Fe}_2\text{O}_3(\text{s})$
  - (c)  $2\text{H}_2\text{O}_2(\text{l}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$
  - (d)  $\text{Cu}^{2+}(\text{aq}) + 4\text{NH}_3(\text{aq}) \rightarrow [\text{Cu}(\text{NH}_3)_4]^{2+}(\text{aq})$
13. In which one of the following equations is sulfuric acid acting as an oxidising agent?
- (a)  $\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{HCl} + \text{NaHSO}_4$
  - (b)  $\text{HCOOH} + \text{H}_2\text{SO}_4 \rightarrow \text{CO} + \text{H}_3\text{O}^{+} + \text{HSO}_4^{-}$
  - (c)  $2\text{Br}^{-} + 5\text{H}_2\text{SO}_4 \rightarrow \text{Br}_2 + \text{SO}_2 + 2\text{H}_3\text{O}^{+} + 4\text{HSO}_4^{-}$
  - (d)  $\text{Ba}(\text{NO}_3)_2 + \text{H}_2\text{SO}_4 \rightarrow \text{BaSO}_4 + 2\text{H}^{+} + 2\text{NO}_3^{-}$

14. Car batteries are of the lead-acid type. The overall reaction which occurs as the battery discharges is:



Which one of the following statements about the recharging process is true?

- (a) The pH of the solution in the battery increases.
  - (b) All  $\text{Pb}^{2+}$  ions in the battery are oxidised to  $\text{Pb}^{4+}$
  - (c) The lead plates in the battery dissolve as  $\text{Pb}^{2+}$  ions are produced.
  - (d)  $\text{Pb}^{2+}$  ions are either oxidised or reduced depending on the electrode they are near.
15. Which of the following statements best describes the function of a hydrogen/oxygen fuel cell?
- (a) It converts heat energy from a chemical reaction to electrical energy.
  - (b) It stores electrical energy produced from the reaction between oxygen and hydrogen.
  - (c) It converts energy from the oxidation of hydrogen directly to electrical energy.
  - (d) It promotes the reaction between hydrogen and oxygen using an external energy source.

**The next two questions refer to the following information:**

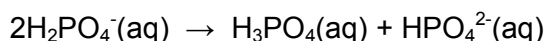
Metal X reacts with water to produce hydrogen.

16. Which one of the following is X behaving as?
- (a) Acid
  - (b) Base
  - (c) A reducing agent.
  - (d) An oxidising agent.
17. Given the further information that
- I the reaction of X with water is extremely vigorous.
  - II X is in period 4
  - III X forms a solid hydrogencarbonate

Which one of the following is the most probable identify of X?

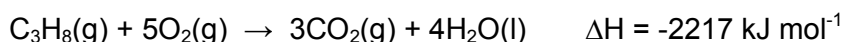
- (a) Calcium
- (b) Potassium
- (c) Magnesium
- (d) Sodium

18. Which one of the following best describes the role of  $\text{H}_2\text{PO}_4^-$  in the equation below:



- (a)  $\text{H}_2\text{PO}_4^-$  is acting only as an acid.
- (b)  $\text{H}_2\text{PO}_4^-$  is acting as both an acid and a base.
- (c)  $\text{H}_2\text{PO}_4^-$  is acting only as a reducing agent.
- (d)  $\text{H}_2\text{PO}_4^-$  is acting as both an oxidising and reducing agent.

19. LP gas, which is used as a fuel in camping stoves, consists mainly of propane. Propane burns in oxygen according to the equation:



Which one of the following statements about this reaction is true?

- (a) Propane is acting as an oxidising agent.
- (b) The reaction is endothermic.
- (c) The chemical potential energy of the products is more than the chemical potential energy of the reactants.
- (d) One mole of propane produces 2217 kJ of heat energy on complete combustion.

20. The following question refer to the structures given below:

- I  $\text{CH}_3(\text{CH}_2)_2\text{CH}_3$
- II  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$
- III  $\text{CH}_3\text{CH}(\text{CH}_3)_2$
- IV  $(\text{CH}_3)_4\text{C}$
- V  $\text{CH}_3\text{C}(\text{CH}_3)_3$

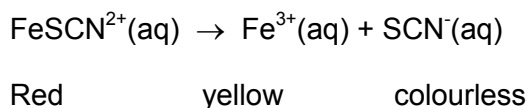
Which one of the following lists different isomers of  $\text{C}_4\text{H}_{10}$ ?

- (a) I and II
- (b) II and IV
- (c) III and V
- (d) II and III

21. Which one of the following lists the solubilities of pentane, propan-1-ol and propanone in order of decreasing solubility in water?

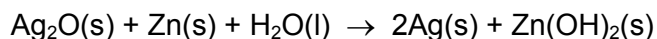
- (a) pentane > propanone > propan-1-ol
- (b) propanone > pentane > propan-1-ol
- (c) propan-1-ol > pentane > propanone
- (d) propan-1-ol > propanone > pentane

22. Iron(II) thiocyanate  $[\text{Fe}(\text{SCN})_3]$  dissolves readily in water to give a red solution. The red colour is due to the presence of hydrated  $\text{FeSCN}^{2+}$  ions. The equilibrium between the undissociated  $\text{FeSCN}^{2+}$  ions and the  $\text{Fe}^{3+}$  and  $\text{SCN}^-$  ions can be represented by the equation:



If 2.00 g of iron(II) thiocyanate is dissolved in 100 mL of distilled water, which one of the following will increase the concentration of iron(III) ions in the mixture?

- (a) Adding 2 mL of water to the mixture.  
(b) Adding sodium hydroxide to the mixture.  
(c) Adding a solution of iron(III) chloride to the mixture  
(d) Adding sodium thiocyanate solution to the mixture.
23. Which one of the following will have the lowest hydrogen ion concentration?
- (a)  $1.0 \text{ mol L}^{-1} \text{ H}_3\text{PO}_4$   
(b)  $1.0 \text{ mol L}^{-1} \text{ HCl}$   
(c)  $\text{H}_2\text{O}$   
(d)  $1.0 \text{ mol L}^{-1} \text{ CH}_3\text{COONa}$
24. The cell reaction occurring in some 'button' batteries as current is drawn is

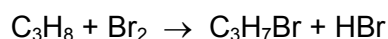


Which one of the following statements about the electrochemical cell is correct?

- (a) Zinc forms the anode and is oxidized.  
(b) Silver forms the anode and is oxidized.  
(c) Zinc forms the cathode and is reduced.  
(d) Silver oxide forms the anode and is oxidized.

fdasfj

25. Consider the following reaction:



Which of the following can this reaction be classified as?

- I        addition  
II       substitution  
III      redox
- (a) I only  
(b) II only  
(c) I and III only  
(d) II and III only



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

This section has **12** questions. Answer **all** questions. Write your answers in the space provided.

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.
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Suggested working time for this section is 60 minutes.

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**Question 26****(2 marks)**

Write the equilibrium constant expression for each of the following.

Equation	$\text{HCN}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{CN}^-(\text{aq})$
Equilibrium constant expression	

(1 mark)

Equation	$\text{As}_4\text{O}_6(\text{g}) + 6 \text{C}(\text{s}) \rightleftharpoons \text{As}_4(\text{g}) + 6 \text{CO}(\text{g})$
Equilibrium constant expression	

(1 mark)

**Question 27**

**(10 marks)**

The amide ion,  $\text{NH}_2^-$ , is a strong base in an aqueous solution.

(a) Write an equation for the hydrolysis of the amide ion. (2 marks)

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(b) A solution of sodium amide in water was found to have a pH of 10.3. Calculate the concentration of the hydrogen ions in  $\text{mol L}^{-1}$ . (1 mark)

(c) A buffer solution can be produced from ammonia and ammonium chloride in solution.

(i) Write an equation for the buffer produced from this combination. (2 marks)

(ii) Explain, using Le Chatelier's Principle, why the addition of a small amount of sodium hydroxide solution would have minimal impact on the pH of the buffer solution. (3 marks)

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(iii) Explain why a sodium amide/ammonia mixture could not be used as a buffer solution. (2 marks)

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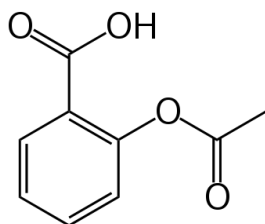
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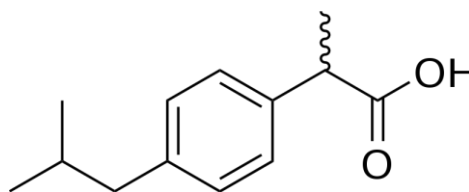


**Question 29****(8 marks)**

A sample of white powder was known to be either ibuprofen or aspirin (the structures for each are given below). When 1.22 g of the compound was vapourised at 250°C, it was found to occupy 0.172 L at 171 kPa.



Aspirin



Ibuprofen

- (a) Calculate the molar mass of the compound. (2 marks)
- (b) Determine the molecular formula each of the compounds from their structural formulas. (4 marks)
- (c) Which of the above two compounds is the painkiller analysed? (2 marks)

**Question 30****(4 marks)**

Write the equation for the reaction that occurs in each of the following procedures. If no reaction occurs, write 'no reaction'. For full marks, chemical equations should refer only to those species consumed in the reaction and the new species produced. These species may be ions [for example  $\text{Ag}^+(\text{aq})$ ], molecules [for example  $\text{NH}_3(\text{g})$ ,  $\text{NH}_3(\text{aq})$ ,  $\text{CH}_3\text{COOH}(\ell)$ ] or solids [for example  $\text{BaSO}_4(\text{s})$ ,  $\text{Cu}(\text{s})$ ,  $\text{Na}_2\text{CO}_3(\text{s})$ ].

(a) Acetic acid solution is added to solid cobalt(II) carbonate. (2 marks)

Equation: \_\_\_\_\_

(b) Methanol is warmed with excess acidified potassium dichromate. (2 marks)

Equation: \_\_\_\_\_

**Question 31****(4 marks)**

Write observations for any reactions that occur in the following procedures. In each case describe in full what you would observe, including any

- colours
- odours
- precipitates (give the colour)
- gases evolved (give the colour or describe as colourless).

If no change is observed, you should state this.

(a) Excess sodium hydroxide is added to copper(II) sulfate solution. (2 marks)

Observation: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

(b) Zinc metal is added to excess nickel(II) nitrate solution. (2 marks)

Observation: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**Question 32****(6 marks)**

Sodium tripolyphosphate,  $\text{Na}_5\text{P}_3\text{O}_{10}$  has been used as a filler in detergents. The main source of this compound is phosphate rock, an ore consisting mainly of calcium phosphate ( $\text{Ca}_3(\text{PO}_4)_2$ ) and silicon dioxide ( $\text{SiO}_2$ ).

Calculate the mass of  $\text{Na}_5\text{P}_3\text{O}_{10}$  that can be produced from the complete conversion of phosphorous from processing 54.3 tonne (1 tonne =  $1 \times 10^6$  g) of an ore that contains 45% by mass of calcium phosphate.

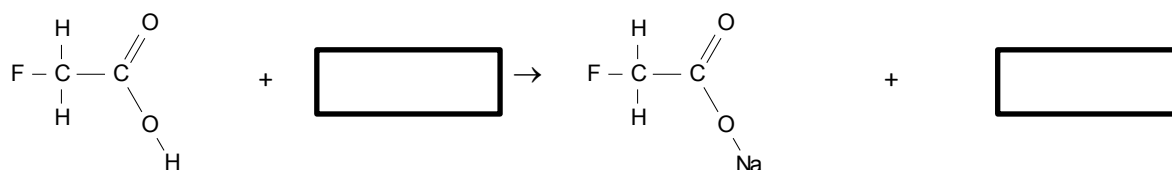
(a) Calculate the mass of calcium phosphate in the ore. (2 marks)

(b) Calculate the number of moles of phosphorus in the calcium phosphate. (2 marks)

(c) Calculate the mass of  $\text{Na}_5\text{P}_3\text{O}_{10}$  that could be produced from the mass of calcium phosphate in (a). (2 marks)

**Question 33****(2 marks)**

1080 is the common name for the rabbit and fox poison sodium monofluoroethanoate. This compound is produced from fluoroacetic acid. Complete the following equation by adding the missing reactant and product.



**Question 34****(6 marks)**

For each species listed in the table below, draw the structural formula, representing all valence shell electron pairs either as : or as — **and** state or draw the shape of the molecule or ion.

(for example, water  $\text{H}:\ddot{\text{O}}:\text{H}$  or  $\text{H}-\ddot{\text{O}}-\text{H}$  or  $\text{H}-\bar{\text{O}}-\text{H}$  bent

<b>Molecule</b>	<b>Structural formula (showing all valence shell electrons)</b>	<b>Shape (sketch or name)</b>
Carbonate ion $\text{CO}_3^{2-}$		
Methanal $\text{CH}_2\text{O}$		
Carbon disulphide $\text{CS}_2$		

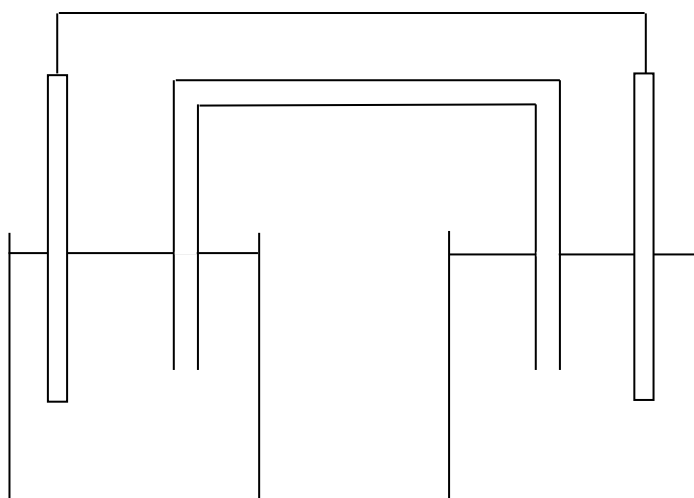




**Question 36**

**(9 marks)**

Below is a diagram of an electrochemical cell constructed from  $\text{Ag}/\text{Ag}^+$  and  $\text{Au}/\text{Au}^{3+}$  half cells with an ammonium chloride salt bridge.



- (a) Label the cell showing (4 marks)
- (i) The anode and the cathode
  - (ii) The direction of electron flow
  - (iii) The direction of ion flow within the half-cells and the salt bridge

- (b) Write half-equations for the oxidation and reduction reactions. (2 marks)

Oxidation

Reduction

- (c) Why would sodium carbonate solution be an inappropriate choice for the salt bridge? (1 mark)

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- (d) After the cell has been operating for some time describe the appearance of each electrode. (2 marks)

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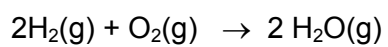
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**Question 37****(5 marks)**

A fuel cell was supplied with 0.663 g of hydrogen and 1.87 L of oxygen at 345 kPa at a temperature of 150°C. The reaction between oxygen and hydrogen can be represented as:



- (b) What volume of water would be produced from this reaction at 150°C, assuming the reaction is 65 % efficient?

**End of Section Two**

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

This section contains **six (6)** questions. You must answer **all** questions. Write your answers in the space provided.

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.

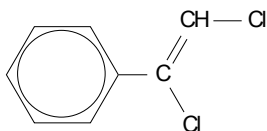
- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
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Suggested working time for this section is 70 minutes.

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**Question 38****(9 marks)**

Consider the structural formula below



(a) Write an equation for the reaction between this compound and liquid bromine. (2 marks)

(b) Describe fully what you would expect to observe when a few drops of bromine liquid are added to this compound. (2 marks)

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(c) What type of polymer would be produced from this compound? (1 mark)

(d) Draw part of this polymer showing at least three repeating units. (2 marks)

(e) There are two isomers of this compound that are cis and trans isomers. Draw these structures. (2 marks)

Structure





**Question 40****(13 marks)**

The chromium content in a sample can be determined by oxidising the chromium to sodium dichromate with excess persulfate solution, boiling to destroy the excess oxidant and then titrating the acidified dichromate solution with standard ammonium iron(II) sulfate solution. Using this method a 7.598 g sample of a chromium containing mineral was converted into an acidified solution of sodium dichromate and dilute to 250.0 mL. A 20.00 mL sample of this solution was then titrated against  $0.399 \text{ mol L}^{-1}$  ammonium iron(II) sulfate solution and the following data obtained:

	1	2	3	4
Final volume	25.65	25.46	27.00	25.33
Initial volume	0.25	1.24	2.76	1.12
Titre				

(a) Write a balanced equation for the reaction. (3 marks)

(b) Calculate the percentage by mass of the chromium in the mineral. (8 marks)



(c) Why doesn't this titration need an indicator?

(2 marks)

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**Question 41****(17 marks)**

Tooth enamel consists mainly of a substance called hydroxyapatite. This is the hardest substance in the body. Tooth cavities are caused when acids dissolve tooth enamel. The formula for hydroxyapatite can be represented by  $\text{Ca}_x(\text{PO}_4)_y(\text{OH})_z$ .

- (a) A 5.00 g sample of hydroxyapatite was dissolved in excess dilute hydrochloride acid. Excess barium chloride was added to precipitate the phosphate ions to produce barium phosphate ( $\text{Ba}_3(\text{PO}_4)_2$ ). The mass of precipitate obtained was 9.00 g. A second 5.00 g sample of hydroxyapatite was also dissolves in acid and excess sodium fluoride solution was added to precipitate the calcium ions to form calcium fluoride. 2.94 g of calcium fluoride was obtained.

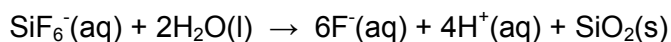
Calculate the empirical formula of hydroxyapatite and show all working. (7 marks)

The acids that react with the hydroxyapatite are formed by the interaction of some bacteria with sugars and carbohydrates that can be found in the plaque that sticks to teeth.

Fluoride ions will react with hydroxyapatite and replace the  $\text{OH}^-$ . This mineral is more resistant to reaction with acids because the fluoride ion is a weaker base than  $\text{OH}^-$ .

Since fluoride ions are so effective at preventing tooth decay, they are often added to water supplies. Various compounds can be used, with the most common being  $\text{NaF}$  or  $\text{Na}_2\text{SiF}_6$ .

When sodium silicon hexafluoride is added to water, the following reaction occurs



- (b) What mass of sodium silicon hexafluoride would need to be added to 100 000 L of water to obtain a fluoride ion concentration of 1 ppm? (Assume that 1.00 L = 1.00 kg for water.) (6 marks)

About 80% of all toothpastes sold contain fluoride compounds. Usually the concentration of the fluoride ions is around 0.1 % by mass. The most common compounds are sodium fluoride and sodium monofluorophosphate ( $\text{Na}_2\text{PO}_4\text{F}$ ) and tin(II) fluoride.

The pH of most toothpastes is around 9.

- (d) Explain, with the aid of an equation, why a solution of sodium fluoride is basic.(4 marks)

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**Question 42**

**(16 marks)**

The water corporation monitors the pH of drinking water very closely. They use pH meters that can be calibrated to take the temperature of the water into account to measure the  $[H^+]$ , rather than indicators.

Water self-ionises to a small degree.

- (a) Write an equation for the self-ionisation of water. (1 mark)

At a constant temperature, the self-ionisation of water is at equilibrium. The equilibrium constant expression for this reaction is

$$K_w = [H^+][OH^-]$$

The values for the equilibrium constant at a range of temperatures are given in the table below.

Temperature (°C)	0	10	20	25	30	40	50	100
$K_w (x 10^{-14})$	0.11	0.29	0.68	1.01	1.47	2.92	5.60	51.3
$[H^+] \text{ mol L}^{-1}$	$3.3 \times 10^{-8}$	$5.3 \times 10^{-8}$		$1.0 \times 10^{-7}$		$1.2 \times 10^{-7}$		

- (b) Plot a graph of the temperature vs the  $K_w$  value. (5 marks)



(c) Calculate the missing values for  $[H^+]$  and complete the table. (2 marks)

(d) Calculate the pH of water at  $10^\circ\text{C}$  and  $40^\circ\text{C}$ . (2 marks)

(e) Describe the relationship between  $K_w$  and temperature. (1 mark)

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(f) From your graph, estimate the value of  $K_w$  at  $45^\circ\text{C}$ . (1 mark)

(g) What is the relationship between  $[H^+]$  and temperature? (1 mark)

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(h) From this data, is the ionisation of water an endothermic or exothermic reaction? Justify your answer. (3 marks)

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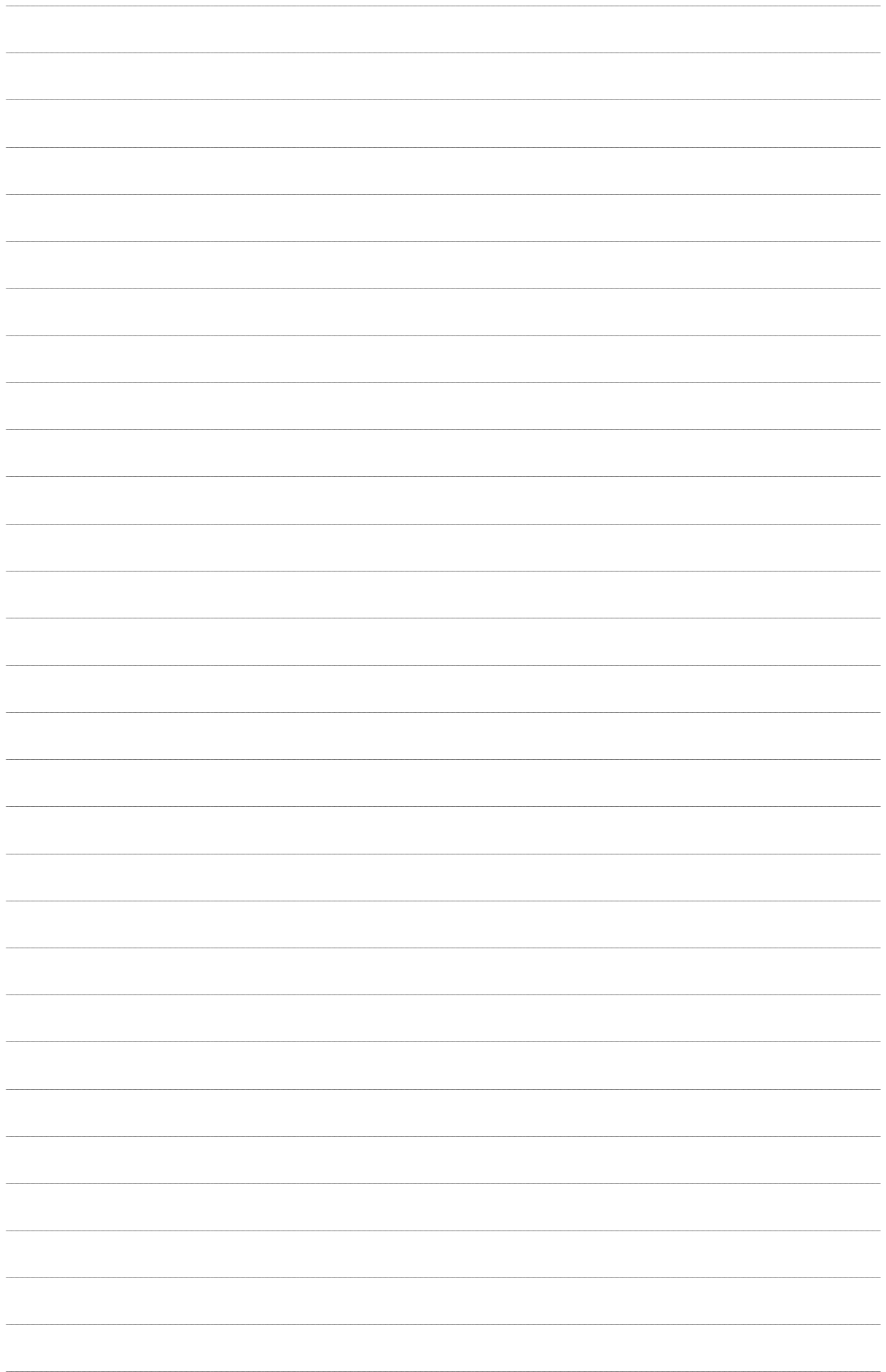
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