* Test papers must be withdrawn after use and stored securely in the school until Friday 29th November.

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**Insert School Logo**

**CHEMISTRY**

**UNITS 1 & 2**

**2019**

**Student Number**: **In** **figures**

**In words** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Teacher:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**TIME ALLOWED FOR THIS PAPER**

Reading time before commencing work: ten minutes

Working time for the 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 Book

**To be provided by the candidate:**

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener,

eraser, correction tape/fluid, ruler, highlighters

Special items: up to three non-programmable calculators approved for use in the WACE examinations

**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 | /50 | /25 |
| Section Two:  Short answer | 8 | 8 | 60 | /70 | /35 |
| Section Three:  Extended answer | 5 | 5 | 70 | /80 | /40 |
|  | | | | | /100 |

**Instructions to candidates**

1. 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 then shade your new answer. Do not erase or use correction fluid/tape. 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 your answers in this Question/Answer Booklet.

2. 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.

3. 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.

4. 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.

5. The Chemistry Data Book is **not** handed in with your Question/Answer Booklet.

**Section One: Multiple-choice 25% (50 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 then shade your new answer. Do not erase or use correction fluid/tape. 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: 50 minutes.

1. An atom has 16 neutrons and a mass number of 31. What is the chemical symbol for this atom?
2. P
3. S
4. Ga
5. Ag
6. Consider the flow chart shown below.

salt water

sodium chloride

sodium metal

chlorine gas

evaporation

electrolysis

Which of the following is/are pure substances?

1. Salt water
2. Sodium chloride
3. Sodium metal
4. Chlorine gas

(a) (ii) only

(b) (iii) and (iv) only

(c) (ii), (iii) and (iv) only

(d) all of (i), (ii), (iii) and (iv)

1. All the allotropes of carbon
2. are nanomaterials.
3. are hard and brittle.
4. conduct electricity.
5. are composed of carbon atoms only.
6. The Periodic Table of the Elements arranges the known elements in numerical atomic number order. Which one of the following trends is correct?
   1. Electronegativity increases down the Group.
   2. Atomic radius increases across the Period.
   3. Electronegativity increases across the Period.
   4. First Ionisation Energy increases down the Group.
7. The reason gases are more easily compressed than liquids or solids is because
8. gas molecules move with much greater velocities than the molecules of solids and liquids, allowing gases to adjust more rapidly to a change in volume.
9. gas molecules undergo elastic collisions with the walls of any container and elastic collisions are more easily compressed.
10. the attractive forces between gas molecules is much stronger than those between the particles of solids or liquids.
11. the average distance between gas molecules is much greater than that between the particles of liquids or solids.
12. A fixed mass of gas is placed into a sealed container at a given temperature. Which of the following statements is **false**?
13. As the pressure of a gas is slowly increased, the kinetic energy of the gas molecules slowly increases.
14. Any gas at a given temperature will have the same average kinetic energy.
15. The volume of the gas varies directly with the temperature in Kelvins if the pressure is kept constant.
16. Molecules of a gas will travel in random, straight line motion, except when they hit the walls of the container or each other.
17. If 1.0 mol L-1 hydrochloric acid was poured into a test tube containing small pieces of magnesium metal, which of the following would **not** be observed?
18. The silver metal would dissolve.
19. A colourless, odourless gas would be produced.
20. The solution would become blue in colour.
21. The test tube would feel warm
22. According to the Laws of Conservation of Energy and Mass, which statement is **not** correct about the combustion of natural gas or methane?

CH4(g) + 2 O2(g) → CO2(g) + 2 H2O(g) + 882 kJ

1. The mass of carbon in the reactants is equal to the mass of carbon in the products.
2. The number of atoms of hydrogen in the reactants is equal to the number of atoms of hydrogen in the products.
3. The moles of oxygen in the reactants is equal to the moles of oxygen in the products.
4. The enthalpy of the reactants is equal to the enthalpy of the products.

**Questions, 9, 10 and 11 relate to the reaction below.**

When ammonia and hydrogen chloride gases are mixed, the formation of a ‘white smoke’ can be observed. This reaction can be represented by the following chemical equation.

NH3(g) + HCl(g) → NH4Cl(s)

The rate of this reaction is very fast. The NH4Cl(s) can be seen forming quickly when the reaction is carried out at room temperature and at normal atmospheric pressure.

1. This suggests that the activation energy is likely to be
2. zero.
3. small.
4. large.
5. extremely large.

In order to investigate the rate of this reaction, the total mass of NH4Cl(s) produced was measured at various time points. The **solid line** on the graph below illustrates the data collected.

**C**

**B**

**A**

1. Which statement regarding the measured rate of reaction (solid line) is **not** correct?
2. From 0-5 seconds the average reaction rate is 0.12 g sec-1.
3. From 5-10 seconds the average reaction rate is 0.07 g sec-1.
4. After 10 seconds the reaction rate is zero.
5. The reaction rate is fastest immediately after Time = 0.
6. If the same number of moles of reactants were mixed at higher pressure, which line on the graph above most accurately predicts the expected results? (Assume all other reaction conditions remain unchanged.)
7. A
8. B
9. C
10. It would be the same as the original solid line.
11. A drop of 8 mol L–1 hydrochloric acid is added to 100 mL of water. The new solution is best described as
12. a weak acid.
13. a solution with a pH above 7.
14. a weak base.
15. a dilute strong acid.
16. If salt is added to a hot solution of salt water until some salt remains at the bottom of the beaker and then the solution is slowly returned to room temperature, the solution will most likely be
17. saturated.
18. supersaturated.
19. unsaturated.
20. under saturated.

**Questions 14 and 15 relate to the following four organic compounds.**

|  |  |
| --- | --- |
| **A** | **B** |
| **C** | **D** |

1. The correct IUPAC name for
2. A is 3,4-dichloro-1-methylhexane.
3. B is 3-b**rom**o-2,3-dimethylpentane.
4. C is 3,3,3-trifluorobut-1-ene.
5. D is 2-chloro-2,3-dimethylpent-3-ene.

1. If a sample of C was mixed with water in the presence of an appropriate catalyst, the most likely product(s) would be







1. c







Consider the following information regarding the boiling point of four of the hydrogenhalides.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | HF | HCl | HBr | HI |
| Boiling point (°C) | 19.5 | -85.1 | -66.8 | -35.4 |

1. Which of these statements are correct?
2. HF is the most polar.
3. HF has the strongest hydrogen bonds.
4. HF has the strongest dipole-dipole forces.
5. HF has the strongest dispersion forces.
6. HF has the strongest intermolecular forces.
7. (i), (ii) and (iii) only
8. (i), (ii) and (v) only
9. (ii), (iii) and (iv) only
10. (i), (ii), (iii) and (v) only

**Questions 17 and 18 refer to the three indicators listed below.**

The diagram below provides information about three different indicators and the colours they display at various pH levels.

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

pH

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| methyl red | red | | yellow | | |
| phenol red | yellow | | | red | |
| thymol blue | red | yellow | | | blue |

1. An unknown substance was tested with all three indicators and turned yellow in each case. Therefore
2. the substance is acidic.
3. the substance is basic.
4. the substance is neutral.
5. not enough information is available to make a conclusion.
6. Two substances were tested with thymol blue. One turned red, while the other turned blue. Which statement is **not** correct regarding the red solution?
7. The red solution is more acidic.
8. The red solution has a lower hydrogen ion concentration.
9. The red solution has a lower hydroxide ion concentration.
10. The red solution has a lower pH.
11. Choose the **correct** statement regarding the behaviour of electrons during bonding.
12. In metallic bonding, electrons are transferred.
13. In ionic bonding, electrons are shared.
14. In covalent molecular bonding, electrons are delocalised.
15. In covalent network bonding, electrons are localised.
16. A beaker contained 0.1 mol L-1 sodium chloride (NaCl) solution. Whilst the conductivity of this solution was being measured, an equal volume of 0.1 mol L-1 silver nitrate (AgNO3) solution was poured slowly into the sodium chloride. As the two solutions were being mixed, the measured current would

(a) increase.

(b) remain constant.

(c) decrease.

(d) become zero.

1. Substance X has the following properties;
   * Low boiling point
   * Dissolves in water
   * Does not conduct electricity when in aqueous solution

Substance X is most likely

1. ionic.
2. polar covalent molecular.
3. non-polar covalent molecular.
4. covalent network.
5. Thin layer chromatography (TLC) can be used to analyse the various natural sweeteners found in food and drink. The following table gives some data regarding the Rf values (see formula below) of different natural sweeteners.

|  |  |
| --- | --- |
| **Sweetener** | **Rf** |
| Glucose | 0.60 |
| Fructose | 0.60 |
| Sucrose | 0.55 |
| Maltose | 0.50 |
| Maltotriose | 0.41 |
| Maltotetraose | 0.30 |
| Maltopentaose | 0.22 |
| Maltohexaose | 0.16 |

A small amount of food was analysed by TLC under the same conditions used to produce the data above. This plate is shown below.

solvent front = 11.2 cm

6.72 cm

6.16 cm

2.46 cm

Which sweetener is **least** likely to be present in this food sample?

1. Sucrose
2. Maltose
3. Glucose
4. Fructose
5. Consider the partially completed table below and choose the **correct** alternative.

|  |  |
| --- | --- |
| **Name** | **Formula** |
| **A** | Fe2(SO4)3 |
| dinitrogen tetrahydride | **B** |
| **C** | H2SO3 |
| lithium hydrogenphosphate | **D** |

1. A is iron(II) sulfate.
2. B is N2O4.
3. C is sulfuric acid.
4. D is Li2HPO4.

**Questions 24 and 25 relate to the data provided below.**

Gas chromatography (GC) can be used to accurately determine a person’s blood alcohol concentration. The following table and chromatogram provide select information about five different substances that commonly undergo analysis.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Name of alcohol** | **Structural diagram** | **Boiling point (**°**C)** |
| **1** | methanol |  | 64.7 |
| **2** | propanone |  | 56.0 |
| **3** | ethanol |  | 78.4 |
| **4** | 2-propanol |  | 82.5 |
| **5** | 2-methyl-2-propanol |  | 82.0 |

1. Which statement regarding the five substances is **not** correct? (All are at the same temperature)
2. Propanone would have the highest vapour pressure.
3. The vapour pressure of ethanol would be lower than the vapour pressure of methanol.
4. 2-propanol has the strongest intermolecular forces.
5. Vapour pressure increases with increasing strength of intermolecular forces.
6. The data from the chromatogram indicates that
7. the components elute in order of boiling point.
8. the components elute in order of molecular mass.
9. the alcohol with greatest concentration is ethanol.
10. the carrier gas would have the longest elution time.

End of Section One

Page has been left blank deliberately

**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.

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Suggested working time: 60 minutes.

**Question 26 (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)

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

1. has the smallest atomic radius? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. has the highest electronegativity? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. is **most likely** to form covalent network bonds? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. is a group 2 metal? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. is most likely to form an anion with 2- charge? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 27 (13 marks)**

Consider the solubility data provided in the table below.

|  |  |
| --- | --- |
| **Substance** | **Solubility in water at 25 °C** |
| KCl | 254 g L-1 |
| SO2 | 94.0 g L-1 |
| I2 | 0.290 g L-1 |

(a) Explain, in terms of intermolecular forces, the differing solubilities of SO2 and I2 in water. (6 marks)

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(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 at 25 °C of KCl, if you were given a 31.75 g sample of KCl(s). (2 marks)

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(d) Calculate the concentration in mol L-1of a saturated solution of KCl at 25 °C. (2 marks)

**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.

Pt

2 CO(g) + O2(g) 2 CO2(g) + 566 kJ

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

Progress of reaction

Potential energy (kJ)

(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 |  |
| Heat of reaction |  |

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)

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**Question 29 (8 marks)**

Volume

Pressure

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)

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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 Volume**

increase / decrease 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)

**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)

brittle

4 types of bonding

solid at room temperature

not solid at room temperature

not brittle

soluble in water

not soluble in water

Y

Z

W

X

(b) Justify the choice of bonding you made for W. (2 marks)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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(c) Justify the choice of bonding you made for X. (2 marks)

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**Question 31 (7 marks)**

Calcium dihydrogenphosphate, Ca(H2PO4)2, and ammonium hydrogenphosphate, (NH4)2HPO4, are both compounds that are commonly found in fertilisers.

(a) Determine the percentage by mass of phosphorus present in calcium dihydrogenphosphate, Ca(H2PO4)2. (2 marks)

(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)

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**Question 32 (7 marks)**

Students are investigating the reaction of a concentrated, weak acid (CH3COOH) with limestone (impure CaCO3).

(a) Write a molecular equation, including states, for the reaction of solid calcium carbonate when it is added to excess ethanoic acid (CH3COOH) solution. (1 mark)

(b) List **two** changes to the method that would increase the rate of this reaction. (2 marks)

One:

Two:

**Question 32** (continued)

(c) Explain, using collision theory, how these **two** changes would increase the reaction rate.

(4 marks)

One:

Two:

**Question 33 (12 marks)**

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

PCl3 SO3 N2 CS2

SiH4 CH2Cl2 Zn(NO3)2 H2S

(a) Draw a Lewis structure (electron dot diagram) for a substance containing no polar bonds. Represent all valence shell electron pairs either as : or –. (1 mark)

|  |
| --- |
|  |

(b) Draw a Lewis structure for an ionic substance. Represent all valence shell electron pairs either as : or –. (3 marks)

|  |
| --- |
|  |

(c) Draw a Lewis structure for a substance matching each molecular shape. Represent all valence shell electron pairs either as : or –. (4 marks)

|  |  |
| --- | --- |
| Triangular planar | V-shaped / Bent |
|  |  |

(d) Draw Lewis structures for two substances that are non-polar. Represent all valence shell electron pairs either as : or –. (4 marks)

|  |  |
| --- | --- |
|  |  |

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 1



Step 2



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

Step 1 reaction: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Step 2 reaction: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Difference:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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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 |
|  |  |

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

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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)

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

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

**Question 35 (10 marks)**

1. Give the **symbol** of an element that matches the following descriptions. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Symbol** |
| An element that exists as diatomic molecules |  |
| A metal that forms monatomic ions with charge 2+ and 3+ |  |
| **Two** elements that form an ion with a –2 charge |  |
| A group 14 metal that forms an insoluble iodide compound. |  |
| An element that forms fullerenes. |  |

1. Give the **name** of a compound that matches the following descriptions. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Name** |
| A weak base. |  |
| A diprotic acid. |  |
| A basic oxide. |  |
| The precipitate formed by reacting solutions of aluminium nitrate and sodium carbonate. |  |
| A cycloalkane that contains 6 carbon atoms. |  |

**Question 36 (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 Mr; water and methane.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Mr | Melting point (°C) | Boiling point (°C) |
| Water (H2O) | 18.016 | 0 | 100 |
| Methane (CH4) | 16.042 | -182 | -162 |

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

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

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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)

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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 Cd2+(aq) ions. It is a toxic substance that can cause damage to the kidneys, liver, lungs and central nervous system. The maximum amount of Cd2+(aq) allowed in potable water, as set by the U.S. Environmental Protection Agency, is 0.005 mg L-1.

Analysis for Cd2+(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 Cd2+(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 Cd2+(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 Cd2+(aq) at a level too high for human consumption? Justify your answer using the graph provided. (3 marks)

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The Cd2+(aq) from a highly contaminated sample of water was to be removed by precipitation. The analysis by AAS determined the concentration of Cd2+(aq) in the water to be 0.0723 mg L-1.

(e) Calculate the concentration of Cd2+(aq) in moles per litre (mol L-1). (2 marks)

A water tank, holding 35 kL of this contaminated water (containing 0.0723 mg L-1 of Cd2+), was treated with **excess** sodium sulfide to precipitate out **all** the cadmium ions. A 2.0 L sample of 0.0125 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.

Cd2+(aq) + Na2S(aq) → CdS(s) + 2 Na+(aq)

(f) Calculate the mass of CdS(s) that would precipitate in the tank. (4 marks)

(g) Calculate the final concentration of Na+(aq) and S2-(aq) in the tank. (5 marks)

**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;

* HNO3(aq)
* K2CO3(aq)
* Ba(OH)2(aq)
* 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)

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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 |  |

1. What volume of 0.1 mol L-1 HNO3 would be required to produce 2.27L of CO2 gas at STP when it is added to potassium carbonate. (3 marks)

(d) Define ‘acids’ and ‘bases’ according to the Arrhenius theory. (2 marks)

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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 |  |
| B |  |
| C |  |
| D |  |

**Question 38 (17 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.

*zymase*

C6H12O6(s) 2 C2H5OH(l) + 2 CO2(g) + 68 kJ

glucose (in flour) ethanol (alcohol)

When bread dough is made, the ingredients are all mixed together, before the dough is kneaded (mixed by hand). 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)

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(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)

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

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Zymase also catalyses the breakdown of coconut oil. One component produced was analysed and found to have the molecular formula of C4H8.

(d) Draw three possible **structural** isomers showing all bonds present. (6 marks)

(e) **Circle** or draw the isomer that would decolourise a solution of bromine water to produce 2,3dibromobutane. (1 marks)

**End of questions**

Spare page44

Spare page45

Spare page46

Spare page47

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| **Marker** | **Questions** | **Marks Available** | **Your Mark** | **Section Total** | **Section** |
| **ALL** | 1 - 25 | 50 |  | / 50 | **1** |
| 2MD | 26 | **7** |  |  |  |
| MD | 27 | **13** |  |  |  |
| SF | 28 | **8** |  |  |  |
| SF | 29 | **8** |  |  | **2** |
| TF | 30 | **8** |  |  |  |
| TF | 31 | **7** |  |  |  |
| JV | 32 | **7** |  |  |  |
| JV | 33 | **12** |  | **/70** |  |
| 3 BL | 34 | 16 |  |  |  |
| KS | 35 | 10 |  |  |  |
| BL | 36 | 22 |  |  | **3** |
| KS | 37 | 15 |  |  |  |
| SH | 38 | 17 |  | **/80** |  |
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