**MARKING KEY**

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**HARRISDALE SENIOR HIGH SCHOOL**

**YEAR 11 SEMESTER 1 2021**

**QUESTION / ANSWER BOOKLET**

CHEMISTRY

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

**Student number: in figures**

**In Words \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

Time allowed for this paper

Reading time before commencing work: ten minutes

Working time: 2 hours 30 minutes

Materials required/recommended for this paper

*To be provided by the supervisor*

This Question/Answer booklet

Multiple-choice answer sheet

Chemistry Data booklet

*To be provided by the candidate*

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters

Special items: up to three calculators, which **do not** have the capacity to create or store programmes or text, are permitted in this ATAR course examination

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 material. 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 examination |
| Section One Multiple–choice | 20 | 20 | 35 | 40 | 25 |
| Section Two Short answer | 7 | 7 | 55 | 56 | 35 |
| Section Three Extended answer | 5 | 5 | 60 | 64 | 40 |
|  |  |  |  | **Total** | 100 |

Instructions to candidates

1. The rules for the conduct of the Western Australian external examinations are detailed in the *Year 12 Information Handbook 2020: Part II Examinations*. Sitting this examination implies that you agree to abide by these rules.

2. Write your answers in this Question/Answer booklet preferably using a blue/black pen. Do not use erasable or gel pens.

3. 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. Do not use erasable or gel pens. 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.

Section Two and Three: Write your answers in this Question/Answer booklet.

4. When calculating numerical answers, show your working or reasoning clearly. Your working should be in sufficient detail to allow your answers to be checked readily and for marks to be awarded for reasoning. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

5. You must be careful to confine your answers to the specific questions asked and to follow any instructions that are specific to a particular question.

6. Supplementary pages for the use of planning/continuing your answer to a question have been provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

7. The Chemistry Data booklet is to be handed in with your Question/Answer booklet.

**Section One: Multiple–choice 25% (40 Marks)**

This section has **20** 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. Do not use erasable or gel pens. 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: 35 minutes.

1. In which one of the following compounds do the two ions have the same electron configuration?

(a) Na2O

(b) LiF

(c) KBr

(d) MgCℓ­2

2. Which one of the following, concerning the structure of atoms, was concluded by English physicist Joseph John (JJ) Thomson?

(a) Electrons could only be found in specific energy levels (quantized).

(b) Atoms are small, hard spheres that are indivisible.

(c) Atoms were divisible, they had smaller constituent parts.

(d) An atom’s positive charge was concentrated in a small, dense centre.

3. Which one of the following **incorrectly** describes the observed changes with increasing atomic number in group 17 (the halogens)?

(a) electronegativity decreases

(b) mass increases

(c) reactivity increases

(d) atomic radius increases

4. The correct IUPAC name for CH3CH2CCH3CHCH3 is

(a) 3–methylpentane.

(b) 2–methylpentane.

(c) 3–methylpent–2–ene.

(d) 2–methylpent–3–ene.

5. Substance “X” is a green, brittle solid that produces toxic gases upon heating. Substance X is soluble in water and conducts electricity when in solution. It cannot conduct electricity when in solid form. Substance X could be

(a) copper carbonate.

(b) nickel chloride.

(c) hydrogen chloride.

(d) iron(III) nitrate.

6. Which diagram correctly represents the bonding in the molecule, methanol, CH3OH?

|  |  |
| --- | --- |
| (a) | (b) |
| (c) | (d) |

7. Select the structure that correctly represents the cyclic compound with the IUPAC name ‘2,3-dichlorocyclopentene.’

|  |  |
| --- | --- |
| (a) | (b) |
| (c) | (d) |

8. Consider the phase changes shown below.

I – melting wax

II – H2O(g) ⇌ H2O(ℓ)

III – freezing water

IV – CO2(s) ⇌ CO2(g)

How many of these phase changes are exothermic?

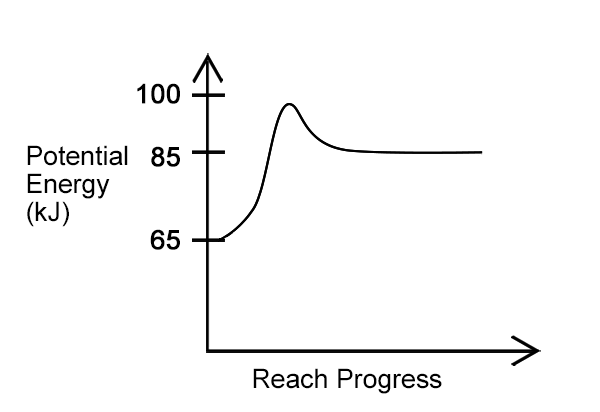
(a) 1

(b) 2

(c) 3

(d) 4

9. For the energy profile diagram below, select the row which correctly classifies the reaction as exothermic or endothermic and provides the correct heat of reaction.



|  |  |  |
| --- | --- | --- |
|  | **Exothermic or Endothermic** | **Heat of reaction** |
| (a) | Exothermic | –85kJ |
| (b) | Endothermic | +85kJ |
| (c) | Exothermic | –20kJ |
| (d) | Endothermic | +20kJ |

10. Which one of the following substances could not be formed when excess iodine reacts with butane in the presence of UV light?

(a) 1–iodobutane

(b) 2–iodobutane

(c) 3–iodobutane

(d) 1, 2–diiodobutane

11. Below is the thermochemical equation for the combustion of butane.

2 C4H10(g) + 13 O2(g) → 8 CO2(g) + 10 H2O(g)     ΔH = –2877 kJ mol L–1

Which one of the following represents the amount of energy released by burning 5.00 mol of butane?

(a) 1159.8 kJ

(b) 7192 kJ

(c) 14 385 kJ

(d) 28 770 kJ

Questions 12 –16 refer to the experiment below ***investigating the energy output of various alcohols***

**The Method**

|  |  |
| --- | --- |
| 1. Measure 100 mL of cold tap water into a conical flask. 2. Clamp the flask at a suitable height so that an alcohol burner can easily be placed below. 3. Weigh the alcohol burner (and cap) containing the alcohol and record this mass and the name of the alcohol. 4. Record the initial temperature of the water in the flask. 5. Place the alcohol burner under the flask and light the wick. 6. Allow the alcohol to heat the water so the temperature rises by 40 °C. |  |
| 1. Replace the cap to extinguish the flame. 2. Reweigh the alcohol burner and cap and record the mass. 3. Calculate 4. Using a fresh 100 mL of cold tap water, repeat the experiment with other alcohols. | |

12. Which one of the following is the dependent variable for this experiment?

(a) the change in temperature of the water

(b) the mass of alcohol used to heat the water

(c) the type of alcohol placed in the burner

(d) the time taken to heat up the water by 40oC

13. Which one of the following is the most important variable that must be controlled to ensure this experiment is valid?

(a) distance between burner and conical flask

(b) initial temperature of the water

(c) initial mass of the alcohol used

(d) same thermometer and conical flask used each time

14. Below is an image of the thermometer with the initial temperature reading. Which of the following is the correct reading?

PPLATO | FLAP | PHYS 7.2: Temperature, pressure and the ideal gas laws

(a) 18 ± 1 oC

(b) 19 ± 1 oC

(c) 18.0 ± 0.5 oC

(d) 19 ± 0.5 oC

15. If the experiment were carried out using a digital thermometer instead of standard thermometer. Which of the following would be true?

I improve accuracy

II improve precision

III reduce random error

IV reduce need for repeat trials

(a) I and II only

(b) I, II and III only

(c) I and IV only

(d) I, II, III and IV

16. The data collected during this experiment is

(a) primary data and it is quantitative.

(b) primary data and it is qualitative.

(c) secondary data and it is quantitative.

(d) secondary data and it is qualitative.

17. Consider the two samples described below.

|  |  |
| --- | --- |
| Sample 1 | 70.0 g of pure copper |
| Sample 2 | 50.0 g of pure potassium |

The number of copper atoms in sample 1

(a) is equal to the number of potassium atoms in sample 2.

(b) is less than the number of potassium atoms in sample 2.

(c) is greater than the number of potassium atoms in sample 2.

(d) is less than 6.022 x 1023.

18. For an endothermic reaction

(a) the enthalpy of the reactants increases.

(b) chemical energy is transformed to heat energy.

(c) the heat of reaction is negative.

(d) there is no overall change in the amount of energy during the reaction.

19. Which one of the following is the **best** description of a sustainable fuel?

(a) a fuel with lower carbon emission than fossil fuels such as coal and natural gas

(b) a fuel produced from organic matter

(c) a fuel produced from renewable resources that can provide energy with causing damage to environment

(d) a fuel that can be mixed with fossil fuels to increase the energy output of a fossil fuel

20. Bioethanol is a biofuel which is produced by the fermentation of corn, potatoes or grain. It is among the best–established biofuels. Which of the following is the correct chemical formula for bioethanol?

(a) CH3COOH

(b) CH3OH

(c) CH3CH2OH

(d) C2H4

**End of Section One**

|  |  |
| --- | --- |
| **Section Two: Short answer** | **35% (56 Marks)** |

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

Supplementary pages for the use of planning/continuing your answer to a question have been provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

Suggested working time: 55 minutes.

|  |  |
| --- | --- |
| **Question 21** | **(9 marks)** |

Below is a table containing the names of common materials used in a range of industries including building, cooking, medicine and cleaning.

|  |  |  |  |
| --- | --- | --- | --- |
| steel | aluminium | brine | sodium chloride |
| potassium permanganate | natural gas | carbon tetrachloride | iodine |

(a) Write the names of the five pure substances in the table below. Write the chemical formula for each substance. (6 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Correct substances listed (Aluminium, Sodium Chloride, Potassium Permanganate, Carbon tetrachloride, Iodine) | 1 |
| correct formula for Aluminium - Aℓ | 1 |
| correct formula for Sodium Chloride – NaCℓ | 1 |
| correct formula for Potassium Permanganate – KMnO4 | 1 |
| correct formula for Carbon tetrachloride - CCℓ4 | 1 |
| correct formula for Iodine – I2 | 1 |
| **Total** | **6** |

(b) State **three** differences between ‘pure’ and ‘impure’ substances. Using examples from above might assist your answer. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Any t**hree** of | |
| Impure substances are made up of two or more pure substances mixed together in any proportion. | 1 |
| Impure substance consist of different kinds of elements/compounds combined together physically and not chemically, whereas in pure substances the elements are chemically combined. | 1 |
| Pure substances have distinct measurable properties, (e.g. melting and boiling points, reactivity, hardness and density) mixtures have properties dependent on the identity and relative amounts of the substances that make up the mixture. | 1 |
| Pure substances have a fixed composition thus have a chemical formula. | 1 |
| Impure substances can be separated by physical means (e.g. filtration, heating and cooling), pure substances cannot. | 1 |
| **Total** | **3** |

**Question 22 (10 marks)**

Below is a list of common cations and anions.

Complete the table above by combining these ions to write an ionic formula for each of the four substances. (4 marks)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Name of substance** | **Cation** | **Anion** | **Chemical formula** | |
| Potassium sulfide | K+ | S2- | K2S | |
| Iron(III) dichromate | Fe3+ | Cr2O72- | Fe2(Cr2O7)3 | |
| Calcium ethanoate | Ca2+ | CH3COO- | Ca(CH3COO)2 | |
| Lead(IV) hydroxide | Pb4+ | OH‑ | Pb(OH)4 | |
| **Description** | | | | **Marks** |
| 1 mark per correct formula | | | | 1 |
| **Total** | | | | **4** |

(b) Describe the nature of, and key parts that make up, an ‘ionic bond’

(2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Electrostatic attraction | 1 |
| Between positive metal ion and negative non-metal ion | 1 |
| **Total** | **2** |

(c) Using potassium sulfide as the example, explain how an ionic bond forms between potassium and sulfur atoms. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Upon reacting, two K atoms lose 1 valance electron to gain a stable electron configuration | 1 |
| Upon reacting, the S atom gains 2 valence electrons to gain a stable electron configuration | 1 |
| The K atom becomes a positively charged K+ ion and the sulfur atom becomes a S2- ion. | 1 |
| These oppositely ions are attracted to each other (electrostatic) | 1 |
| **Total** | **4** |

**Question 23 (5 marks)**

A beaker has the following three substances mixed together.

 water – H2O(s)

 potassium nitrate – KNO3(s)

 barium sulfate – BaSO4(s)

Write a clear step–by–step method that could be used to successfully separate this mixture into its three individual components.

|  |  |
| --- | --- |
| Diagram   1. Flotation or decantation to get ice 2. Filtration or decantation to remove insoluble BaSO4 3. Evaporation to get potassium nitrate   All three diagrams for 1 mark | |
| Add liquid H2O to beaker to float the ice and dissolve the potassium nitrate | 1 | |
| Filtration or decantation method described to remove insoluble BaSO4 from water and potassium nitrate | 1 | |
| Evaporation method described to separate water and potassium nitrate | 1 | |
| Clear step-by-step method provided | 1 | |
| **Total** | **5** | |

|  |  |
| --- | --- |
| **Question 24** | **(10 marks)** |

Below is an incomplete graph showing the 1st ionisation energies of the first 19 elements of the Periodic Table. Hydrogen and helium have been shown on the graph.

**Chart, line chart

Description automatically generated**

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Drop in ionisation energy from helium to lithium | 1 |
| Drop ionisation energy shown from neon to sodium and also argon to potassium | 1 |
| Gradual increase in first ionisation energy from lithium through neon and from sodium to argon | 1 |
| Gradual drop visible when comparing Li, Ne and Ar | 1 |
| **Total** | **4** |

1. Another property that sees a trend across the periodic table is ‘electronegativity.’

Describe this property. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Electronegativity is a relative measurement / property of an atom | 1 |
| Measuring how strongly atoms attract electrons to themselves | 1 |
| **Total** | **2** |

(c) State the trend in electronegativity across a period of the periodic table. Use your understanding of atomic structure explain why this trend occurs. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Electronegativity increases as move from left to right across a period of the periodic table. | 1 |
| This is because the number of protons in nucleus increases making nucleus more positively charged | 1 |
| Increasing the electrostatic attraction between electrons and the nucleus, therefore the more strongly attract electrons | 1 |
| **Total** | **3** |

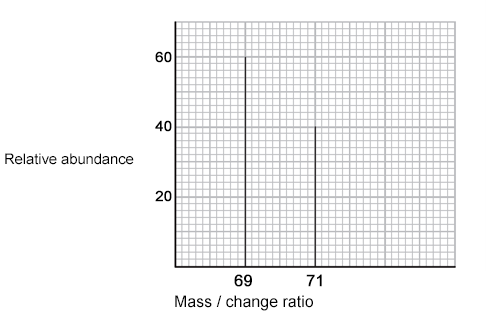
(d) Complete the sentence by circling the correct word. (1 mark)

‘As the first ionisation energy of an atom increases; the electronegatively of the atom. Increases / decreases.

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Increases | 1 |
| **Total** | **1** |

**Question 25 (6 marks)**

The mass spectrum for an element is shown below



**Mass / Change Ratio**

**Relative Abundance**

1. State **two** differences and **one** similarity between the isotopes represented above.

(3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| 2 different isotopes of the element | 1 |
| Different – Number of neutrons, mass and/or abundance | 1 |
| Same– Number of protons, electrons and chemical properties | 1 |
| **Total** | **3** |

1. Calculate the relative atomic mass of the element using the data in the mass spectrum.

|  |  |
| --- | --- |
| **Description** | **Marks** |
| 60% abundance for isotope 69 and 40% abundance for isotope 71 | 1 |
| Working shown to calculate;  relative atomic mass = (0.6 x 69) + (0.4 x 71) = | 1 |
| 69.8 amu  No units -1 | 1 |
| **Total** | **3** |

**Question 26 (7 marks)**

|  |  |  |
| --- | --- | --- |
| **Structural formula** | **IUPAC name** | |
|  | Ethane | |
|  | 2-methyl pentane | |
|  | 1,2-dichloro butane | |
| Review Exam III 1 CHEM 1014 Chem 1014 Review In-Class Problem Set November  11, 1999 Fall 1999 Name__________________________ TA | 3-methyl octane | |
|  | 5,6 dibromo hex-1-ene | |
| CH3CH2CH2CHCH2 | Pent-1-ene | |
| CH3CH2CHCH3CH2CH2CHBrCH3 | 2-bromo-5-methyl heptane | |
| **Description** | | **Marks** |
| 1 mark per correct name | | 1-7 |
| **Total** | | **7** |

**Question 27 (9 marks)**

Chlorine can be produced by various processes. One method is by the [electrolysis](https://en.wikipedia.org/wiki/Electrolysis) of a [sodium chloride](https://en.wikipedia.org/wiki/Sodium_chloride) solution ([brine](https://en.wikipedia.org/wiki/Brine)). Another method is by the direct oxidation of hydrogen chloride with oxygen.

(a) Below are two equations that represent two different methods. Write coefficients to balance each of these equations. (2 marks)

|  |  |
| --- | --- |
| **Electrolysis:**  **2** NaCℓ (aq) + **2** H2O(ℓ) → **1** Cℓ2(g) + **1** H2(g) + + **2** NaOH(aq)  **Direct oxidation:**  **4** HCℓ (aq) + **1** O2(g) → **2** Cℓ2(g) + **2** H2O(ℓ) | |
| **Description** | **Marks** |
| Electrolysis equation correctly balanced | 1 |
| Direct oxidation equation correctly balanced | 1 |
| **Total** | **2** |

Chlorine can be prepared in the laboratory by the reaction of manganese dioxide with hydrochloric acid, HCℓ(aq), as described by the balanced chemical equation below.

MnO2(s) + 4 HCℓ (aq) ⟶ MnCℓ2(aq) + 2 H2O(ℓ) + Cℓ2(g)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Conversion of kg to g | 1 |
| n(MnO2) = m/M = 2500g / 86.94gmol-1 = 28.76mol | 1 |
| n(HCℓ­) = 4/1 x n(MnO2) = 115.02mol | 1 |
| m(HCℓ­) – nxM = 115.02mol x 36.458 gmol-1 = 4193g = 4.19kg | 1 |
| **Total** | **4** |

Calculate the mass of chlorine that would be required to produce 100 g of Aluminium Chloride (AℓCℓ3) (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(AlCℓ­3) = m/M = 100g / 133.33 gmol-1 = 0.750 mol | 1 |
| n(Cℓ2­)required = 3/2 x n(AlCℓ­3)  = 3/2 x 0.750 mol  = 1.125 mol | 1 |
| m(Cℓ2­) required = nxM = 1.125mol x 70.9 gmol-1 = 79.76g | 1 |
| **Total** | **3** |
| Using % or ratio accepted | |

**End of Section Two**

|  |  |
| --- | --- |
| **Section Three: Extended answer** | **40% (64 Marks)** |

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

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 and include appropriate units where applicable.

Supplementary pages for the use of planning/continuing your answer to a question have been provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

Suggested working time: 60 minutes.

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

**Question 28 (15 marks)**

Below is a list of solid substances with some of their physical properties

|  |  |  |  |
| --- | --- | --- | --- |
| **Name of substance** | **Melting point** | **Conductivity in solid form** | **Conductivity when mixed with water** |
| **Copper** | 1085 oC | High | Not tested |
| **Copper(II) sulfate** | 110 oC | Nil | Medium |
| **Chromium(III) sulfate** | 90 oC | Nil | Medium |
| **Sulfur** | 115 oC | Nil | Nil |

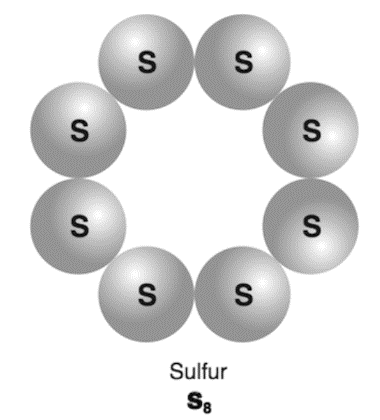
(a) Of the four substances, copper is the substances with the highest melting point and highest conductivity. Use your understanding of the structure of copper to explain these observations. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Electrostatic attraction between metal cation and delocalized electrons is strong | 1 |
| Requiring a large amount of heat energy to overcome this attraction, therefore high boiling point. | 1 |
| Delocalised electrons able to freely flow amongst the metal cation lattice | 1 |
| These free moving charged particles allow the metal to conduct electricity | 1 |
| **Total** | **4** |

(b) Explain why copper(II) sulfate and chromium(III) sulfate can conduct electricity when in aqueous solution but not when solid. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Both dissolve in water and dissociate | 1 |
| Producing free moving ions in solution | 1 |
| These free moving charged particles allow the solution to conduct electricity (as the cations flow to the negative terminal and the anions flow to the positive terminal) | 1 |
| In solid form the ions are stuck in a fixed position in the lattice and therefore cannot flow to allow electricity to be conducted | 1 |
| **Total** | **4** |

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Copper sulfate breaks apart producing 2 ions per formula unit  CuSO4 → Cu2+ + SO42- | 1 |
| Chromium sulfate breaks apart producing 5 ions per formula unit  Cr2(SO4)3 → 2 Cr3+ + 3 SO42- | 1 |
| The solution of chromium sulfate will have a higher concentration of free moving ions in solution. | 1 |
| **Total** | **3** |

1. Sulfur is classified as a covalent molecular substance; its molecular structure is represented below. Name the bond present within this structure, describe the nature of the bond and classify the bond as either a strong or weak bond.

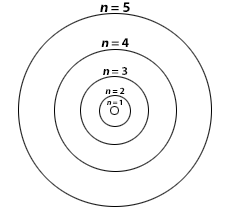
|  |  |
| --- | --- |
| **Description** | **Marks** |
| It is a covalent bond | 1 |
| The electrostatic attraction between the shared valence electrons of sulfur atoms | 1 |
| And the adjacent positively charged nuclei | 1 |
| It is a strong bond | 1 |
| **Total** | **4** |

**Question 29 (13 marks)**

A copper ore mining operation began in the 1970’s in Recsk, Northern Hungary. Unfortunately, as soon as the roadways were finished the activities were suspended because of the decreasing price of copper in the international market. The mine was abandoned, and the roadways and shafts became flooded by ground water.

(a) Rock samples from the site were tested using a flame test and the colour of the flame produced gave a strong indication of high levels of copper. Circle the colour. (1 mark)

|  |  |  |  |
| --- | --- | --- | --- |
| Red | Blue | Green | Orange |

(b) Using the diagram of Bohr’s model of an atom below to **assist** in explaining, how heating an atom like copper in a flame will produce a coloured flame. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| When a metal atom is strongly heated, its electrons absorb the heat energy and jump to a higher energy level | 1 |
| When the electron returns to its original position it gives off the energy it absorbed in the form of light. | 1 |
| A number of different electrons can jump and fall to different energy levels in the atom producing light with specific wavelengths (unique emissions) | 1 |
| The combination of all these emissions gives the metal ion a unique colour during the flame test. | 1 |
| **Total** | **4** |

Copper has leached into the mine water. Concerned that some people had been drinking this water, a scientist decided to use atomic absorption spectroscopy to determine the concentration of copper in the water.

Firstly, he measured the absorbance levels of various solutions with known concentration of copper. The following results were obtained.

|  |  |
| --- | --- |
| **Copper concentration (mgL–1)** | **Absorbance levels (AU)** |
| 1.00 | 0.052 |
| 2.00 | 0.103 |
| 2.50 | 0.128 |
| 4.00 | 0.207 |

(c) Plot these results to produce a calibration curve below. (5 marks)

|  |  |
| --- | --- |
| Chart, line chart  Description automatically generated | |
| **Description** | **Marks** |
| Graph title | 1 |
| labelled axis and units included in labels | 1 |
| Scale of x and y axis correct | 1 |
| Plotting correct | 1 |
| Line of best fit correctly drawn | 1 |
| **-1 if axis are the wrong way around Total** | **5** |

**Question 29** (continued)

Water supplies are continually monitored by the Department of Health to ensure copper levels do not exceed Drinking Water Guidelines. These guidelines set two levels for copper:

 1 mg L–1 for aesthetics to prevent taste and staining problems

 2 mg L–1 to prevent any health–related problems

(d) The absorbance measured for the samples from the mine water are shown below. Use these data to describe any appearance or health issue that might be of concern. (2 marks)

|  |  |
| --- | --- |
| Sample 1 | 0.075 AU |
| Sample 2 | 0.078 AU |
| Sample 3 | 0.077 AU |

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Water may cause staining problems and taste different (not necessarily pleasant to drink) | 1 |
| But not at levels that could cause health related problems (safe to drink) | 1 |
| **Total** | **2** |

(e) State why the scientists analysed three samples rather than only one sample from the mine water. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Increase reliability | 1 |
| **Total** | **1** |

**Question 30 (14 marks)**

Consider the combustion of propane (a fuel derived from fossil fuels) in excess oxygen gas. This reaction is said to have a change in enthalpy (∆H) of –2000 kJ mol–1. The reaction also has an activation energy of approximately 200 kJ.

(a) Write a balanced thermochemical equation for the combustion of propane. (3 marks)

|  |  |
| --- | --- |
| C3H8(g) + 5 O2(g) ⟶ 3 CO2(g) + 4 H2O(ℓ) ∆H = −2000 kJ mol-1  C3H8(g) + 5 O2(g) ⟶ 3 CO2(g) + 4 H2O(ℓ) + 2000 kJ | |
| **Description** | **Marks** |
| Correct formula for reactants and products | 1 |
| Equation balanced | 1 |
| Enthalpy change represented correctly in equation to show exothermic | 1 |
| **Total** | **3** |

(b) In the space below sketch an energy profile diagram being sure to label the reactants, products, change in enthalpy (∆H) and activation energy (Ea). (5 marks)

|  |  |
| --- | --- |
| **Diagram  Description automatically generated**  **-2000Kj** | |
| **Description** | **Marks** |
| Correct shape (H(reactants) > H(products)) | 1 |
| H(reactants) and H(products) labelled | 1 |
| Activation energy labelled | 1 |
| ∆H labelled | 1 |
| ∆H approximately 10 times larger than activation energy | 1 |
| **Total** | **5** |

(c) Explain in terms of bond breaking and bond formation why this reaction is an exothermic reaction. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| More energy is released during bond formation (forming new bonds in the products) | 1 |
| Than is required during in bond breaking (breaking reactant bonds) | 1 |
| If more energy is released than absorbed/required, the outcome is energy is overall released to surroundings therefore the reaction is exothermic | 1 |
| **Total** | **3** |

1. A gas cylinder was known to contain 5.00 kg of propane. Calculate the number of carbon atoms in the cylinder.

(3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(C3H8) = m/M = 5000g / 44.094 = 113.4mol | 1 |
| N(C3H8) = n x NA = 113.4 x 6.022x1023 = 6.83 x 1025 molecules | 1 |
| N(C) = 3 x 6.83 x 1025 molecules = 2.05 x 1026 atoms | 1 |
| **Total** | **3** |

**Question 31 (13 marks)**

Calcium carbonate is used in some toothpastes. To determine the mass of calcium carbonate in one gram of toothpaste, a 10.40 g sample of the toothpaste was reacted with excess hydrochloric acid solution.

When calcium carbonate reacts with hydrochloric acid solution the products are calcium chloride solution, water and carbon dioxide.

1. If the molecular equation describing this reaction is

CaCO3 + 2HCℓ → CaCℓ2 + CO2 + H2O

Write a balanced ionic equation for the reaction taking place, include state symbols. (2 marks)

|  |
| --- |
| CaCO3 (s)  + 2H+(aq) → Ca2+(aq) + CO2(g) + H2O(l) |

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Correct formula and balanced | 1 |
| Substates | 1 |
| **Total** | **2** |

(b) If 3.570 g of carbon dioxide is produced, calculate the mass of calcium carbonate present in the 10.40 g sample. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(CO2) = m/M = 3.570g / 44.01 gmol-1 = 0.08111 mol | 1 |
| n(CaCO3­) = n(CO2) = 0.08111 mol | 1 |
| m(CaCO3­) = n x M = 0.08111 mol x 100.09 gmol-1 = 8.119g | 1 |
| Molar mass of CO2 andCaCO3  correctly worked out | 1 |
| **Total** | **4** |

1. Calculate the mass of calcium carbonate in one gram the toothpaste.

(1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| m(CaCO3­) = 8.119 / 10.40 = 0.781g | 1 |
| **Total** | **1** |

1. By referring to the given equation in part (a) state what assumption has been made about the reaction of the acid with the toothpaste.

(1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| HCl is in Excess | 1 |
| **Total** | **1** |

1. Three students, Ryan, Rhea and Ella conducted an experiment using different quantities of the reactants. The following amounts of each reagent were combined in several trials of the experiment. What mass of the excess reagent is left over if they used 6.67g of CaCO3 and 5.86g of HCℓ in their trials. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(CaCO3­) = m/M = 6.67 / 100.09 = 0.06664 mol  n(HCl) = m/M = 5.86 / 36.428 = 0.160865 mol | 1 |
| SR = CaCO3 / HCl = ½ = 0.5 / 1  AR = CaCO3 / HCl = 0.06664 / 0,160865 = 0.4 / 1 | 1 |
| LR = CaCO3 : Excess = HCl | 1 |
| n(HCl)used = 2 / 1 n(CaCO3­) = 2 x 0.06664 = 0.13328  n(HCl)excess =0.160865 - 0.13328 = 0.027585 | 1 |
| m(HCl) excess  = n x M = 0.027585 x 36.428 = **1.00g** | 1 |
| **Total** | **5** |

**Question 32 (9 marks)**

Silicon dioxide (SiO2), also known as “silica”, is a natural compound made of two of the earth's most abundant materials: silicon (Si) and oxygen (O2).

Carbon dioxide is a chemical compound composed of one carbon and two oxygen atoms. It is often referred to by its formula CO2. It is present in the Earth's atmosphere at a low concentration and acts as a greenhouse gas. In its solid state, it is called “dry ice”.

(a) Calculate the percentage by mass of oxygen in each of these two substances. Showing your working in the table below. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| %(O)in silicon dioxide = 16 gmol-1 x 2 / 60.08 gmol-1 x100 = 53.3% | 1 |
| %(O)in carbon dioxide = 16 gmol-1 x 2 / 44.01 gmol-1 x100 = 72.7% | 1 |
| Both have correct molar masses | 1 |
| **Total** | **3** |

(b) Silica is a very hard solid that can only be melted by heating to temperatures above 1,710 °C. Dry ice is a soft and crumbly solid that is converted to gaseous form with little heating. Use your understanding of the structure and bonding of these substances to explain these differences their properties. (6 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Silica is a covalent network substance so each atom is covalently bonded to other atoms in a lattice | 1 |
| It is these strong covalent bonds that need to be broken (electrostatic attraction between shared electrons and positive nuclei) | 1 |
| Therefore a lot of heat energy is required to overcome/break these covalent bonds giving it a very high melting point | 1 |
| A lot of force is required to overcome/break these covalent bonds giving it great hardness | 1 |
| Dry ice is a covalent molecular substance so whilst covalent bonds hold atoms together weak intermolecular forces hold neighboring molecules together | 1 |
| These forces are much weaker and thus less heat and force is required to overcome these forces making it both easier to vapourize and easy to break (crumbly) | 1 |
| **Total** | **6** |