

### Year 12 Chemistry

**Trial Examination 2012**

**TIME ALLOWED FOR THIS PAPER**

# Reading time before commencing work: Ten minutes

Working time for the paper: Three hours

## MATERIAL REQUIRED/RECOMMENDED FOR THIS PAPER

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

Pens, pencils, calculator satisfying the conditions set by Curriculum Council.

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

This Question/Answer Booklet; Multiple-choice Answer Sheet; Chemistry Data Sheet.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Section 1** | | **Section 2** | | | **Section 3** | | | **Totals** | | |
| Mark | Out of | Q | Mark | Out of | Q | Mark | Out of |  | Mark | Out of |
|  | 25 | 26 |  | 10 | 37 |  | 19 | Section 1 |  | 50 |
|  |  | 27 |  | 8 | 38 |  | 16 | Section 2 |  | 70 |
|  |  | 28 |  | 6 | 39 |  | 16 | Section 3 |  | 80 |
|  |  | 29 |  | 8 | 40 |  | 14 | Total |  | 200 |
|  |  | 30 |  | 4 | 41 |  | 15 |  |  |  |
|  |  | 31 |  | 3 |  |  |  | **Total** |  | **%** |
|  |  | 32 |  | 4 |  |  |  |  |  |  |
|  |  | 33 |  | 6 |  |  |  |  |  |  |
|  |  | 34 |  | 5 |  |  |  |  |  |  |
|  |  | 35 |  | 12 |  |  |  |  |  |  |
|  |  | 36 |  | 4 |  |  |  |  |  |  |
|  |  | Total |  | 70 | Total |  | 80 |  |  |  |

## STRUCTURE OF THE PAPER

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Section | Format | No. of  questions  set | No. of questions to be attempted | Recommend  time (minutes) | Marks Allocated | Marks |
| 1 | Multiple Choice | 25 | ALL | 50 | 25 | 25% |
| 2 | Short Answer | 11 | ALL | 60 | 70 | 35% |
| 3 | Extended Response | 5 | ALL | 70 | 80 | 40% |

**Instructions to candidates**

1. Answer the questions according to the following instructions

**Section 1:** 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 the square and shade a new answer. Do not erase or use correction fluid. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any one question.

**Section 2 and 3**: Write your answers in the Question/ Answer Booklet.

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

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

4. Spare pages are included at the end of the 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 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 Sheet will be collected with your Question/answer Booklet

**Section 1: Multiple-choice 25% [25 Marks]**

This section has **25** questions. Answer **all** questions on the Multiple-choice Answer Sheet provided. Use only 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. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is given for any question.

Suggested working time for this section is 50 minutes.

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1. Which group of elements is arranged in order of increasing electronegativity?

A. Li, F, Si, C

B. Si, C, Li, F

C. Li, C, Si, F

D. Li, Si, C, F

2. Consider the successive ionisation energies of a particular element in the third period.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Ionisation | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th |
| Ionisation energy (MJ mol–1) | 1.02 | 1.91 | 2.92 | 4.96 | 6.28 | 21.3 | 25.4 |

The group to which this element belongs and the charge on its most common and

stable ion, would be:

A. group 5 and 3–

B. group 15 and 3–

C. group 15 and 5+

D. group 17 and 1–

3. Which of the following statements is true about the trends in the periodic table?

A. The melting points of group 16 elements tend to decrease from top to bottom.

B. The melting points of group 14 fluorides tend to increase from top to bottom.

C. Each of the group 14 elements has the highest melting point of their period.

D. The first ionisation energy and the radii of elements in period 3 decrease

from left to right.

4. Which of the following can form hydrogen bonds with water?

NH2CH2COOH HC CH4 CH3CHO

A. CH4 only

B. HC and CH4 only

C. NH2CH2COOH and CH3CHO only

D. NH2CH2COOH only

5. Which of the following represents the correct shapes of each of the molecules

PC3, HCN, F2O and H2CO?

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | PC3 | H2CO | F2O | HCN |
| A. | pyramidal | pyramidal | bent | bent |
| B. | trigonal planar | pyramidal | linear | bent |
| C. | pyramidal | trigonal planar | bent | linear |
| D. | trigonal planar | trigonal planar | linear | linear |

6. Which statement about the behaviour of a catalyst in a chemical reaction is correct?

A catalyst provides an alternative pathway with:

A. a lower activation energy for the forward reaction only.

B. a higher activation energy for the forward reaction only.

C. a lower activation energy for both the forward and reverse reactions.

D. a higher activation energy for both the forward and reverse reactions.

7. Consider the following equilibrium: H2(g) + I2(g) ⇄ 2 HI(g)

The equilibrium constant is 160 at 500 K and 54 at 700 K. This would indicate

that the forward reaction is:

A. fast

B. slow

C. exothermic

D. endothermic

**The next three questions refer to the following equilibrium:**

4 NH3(g) + 5 O2(g) ⇄ 4 NO(g) + 6 H2O(g) ∆H = –908 kJ mol–1

8. The equilibrium constant for this system is given by:

A. [NH3]4 [O2]5

[NO]4 [H2O]6

B. 4[NH3] 5[O2]

4[NO] 6[H2O]

C. [NO]4 \_

[NH3]4 [O2]5

D. [NO]4 [H2O]6

[NH3]4 [O2]5

9. If the temperature of an equilibrium mixture of these gases was increased at constant volume, then:

A. the mass of NH3 would increase and K would increase.

B. the mass of NH3 would increase and K would decrease.

C. the mass of NH3 would decrease and K would increase.

D. the mass of NH3 would decrease and K would decrease.

10. A decrease in the volume of an equilibrium mixture of these gases at constant temperature would cause:

A. a decrease in the amount of NO.

B a decrease in the rate of the forward reaction.

C. the value of K to increase.

D none of the above.

11. Consider the following information regarding two solutions.

Solution 1: 20.0 mL of 0.100 mol L–1 HCO has a pH of 4.27

Solution 2: 20.0 mL of 0.100 mol L–1 HCN has a pH of 5.11

The two solutions are combined. Which of the following would be present in the

mixture at the highest concentration?

A. H3O+

B. HCN

C. HCO

D. CO–

12. The pH of an aqueous solution is found to be 12.00. Which of the following solutions

is consistent with this observation?

A. 1.00 x 10–12 mol L–1 sodium hydroxide.

B. 5.00 x 10–3 mol L–1 barium hydroxide.

C. 1.00 x 10–12 mol L–1 nitric acid.

D. 1.00 x 10–1 mol L–1 potassium hydroxide.

13. Which of the conditions best describes the solutions of the three salts?

|  |  |  |  |
| --- | --- | --- | --- |
|  | KC | Na2HPO4 | NH4NO3 |
| A | neutral | basic | acidic |
| B | acidic | neutral | acidic |
| C | neutral | acidic | basic |
| D | basic | basic | basic |

14. In standardising a sodium hydroxide solution by titrating 20.00 mL aliquots against a

standard hydrochloric acid solution, a student experienced difficulty in obtaining consistent values for the volume of acid added.

Which of the following sequential steps could be responsible for this lack of

precision?

A. The burette was cleaned and rinsed thoroughly with the standard acid

solution before being filled.

B. Several 250 mL conical flasks were washed, and rinsed thoroughly with the

sodium hydroxide solution.

C. A clean pipette was rinsed with the sodium hydroxide solution and a

20.0 mL aliquot was carefully pipetted into each conical flask.

D. To each flask in turn, standard hydrochloric acid solution was added with care

from the burette until the end point was observed, and the volume added

was recorded.

15. Using 0.100 mol L–1 NaOH, a student titrated a 25.0 mL aliquot of a 0.100 mol L–1

weak monoprotic acid, and separately titrated 25.0 mL of a 0.100 mol L–1 strong

monoprotic acid.

Which statement about the volume of base required to reach the equivalence point is correct?

A. The weak acid will require a smaller volume of 0.100 mol L–1 NaOH than the

strong acid.

B. The weak acid will require the same volume of 0.100 mol L–1 NaOH as the

strong acid.

C. The weak acid will require a larger volume of 0.100 mol L–1 NaOH than the

strong acid.

D. The volume of 0.100 mol L–1 NaOH required will depend on the mass of

each acid used.

16. How many different carboxylic acid isomers have the molecular formula C5H10O2?

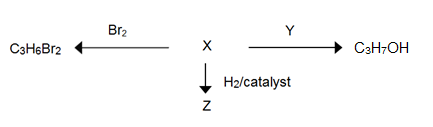
A. 5

B. 4

C. 3

D. 2

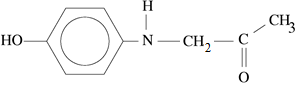
17. Consider the following diagram:



The formulae of substances X, Y and Z are probably:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **X** | **Y** | **Z** |
| A. | C3H8 | NaOH | C3H8 |
| B. | C3H8 | H2O | C3H6 |
| C. | C3H6 | HNO3 | C3H8 |
| D. | C3H6 | H2O | C3H8 |

18. Consider the structure below:



Which of the following correctly identifies two functional groups in this compound?

A. primary amine and ketone

B. alcohol and ketone

C. amino acid and alcohol

D. alcohol and carboxylic acid

19. In which of the following are substances listed in order of increasing boiling point?

A. lithium, sodium, magnesium

B. dimethylpropane, methylbutane, pentane

C. propanoic acid, butanol, butanone

D. NH3, PH3, AsH3

20. Which of the following mixtures would **not** act as a buffer?

A. NaF and HF

B. NH3 and NH4C

C. NaC and HC

D. KCH3COO and CH3COOH

21. In which of the following does the oxidation number of an element decrease by 3?

A. NO → NO3–

B. MnO2 → MnO4–

C. PH4+ → P

D. CrO42– → Cr3+

22. If three beakers were prepared containing:

**I** Fe(s) in nickel(II) nitrate solution

**II** Pb(s) in nickel(II) nitrate solution

**III** Ni(s) in lead(II) nitrate solution

then a reaction could occur in beakers:

A. **II** and **III** only

B. **I** and **III** only

C. **I** only

D. **II** only

23. Pieces of four different metals J, L, M and N were separately placed into four

solutions containing J2+, L2+, M2+ and N2+ ions respectively and the observations

listed below:

**I** Metal L remained unchanged in all four solutions.

**II** Displacement reactions were observed when metal M was placed in

solutions of L2+ and J2+, but not in N2+.

Which of the following electrochemical cells would produce the largest cell potential?

A. L / L2+ // N2+ / N

B. M / M2+ // J2+ / J

C. J / J2+ // L2+ / L

D. L / L2+ // M2+ / M

24. What is the function of the salt bridge in an electrochemical cell?

A. To allow the movement of ions between the two half-cells to maintain

electrical neutrality.

B. To supply the ions necessary for oxidation and reduction.

C. To allow the electrons to move from the anode to the cathode.

D. To keep the level of the solutions equal in both half-cells.

25. In the extraction of gold from its ore, the gold must initially be dissolved into solution.

This occurs by the MacArthur-Forrest process in which the crushed, gold-bearing ore

is mixed with sodium cyanide solution and air passed through it.

The reaction that occurs is:

4 Au(s) + 8 CN–(aq) + 2 H2O() + O2(g) → 4 [Au(CN)2]–(aq) + 4 OH–(aq)

Which one of the following statements is correct?

A. The gold is the oxidant.

B. Cyanide ions are reduced.

C. The oxidation state of the gold changes from 0 to –1.

D. The oxygen acts as the oxidant in the reaction.

**Section 2: Short answer 35% [70 Marks]**

This section has **11** 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.

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

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* Continuing an answer: If you need 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 for this section is 60 minutes.

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**Question 26 [10 marks]**

An electrochemical cell using Cu/Cu2+ and Cr/Cr3+ is shown below.

V

Cr salt bridge Cu

1 mol L-1 Cr3+(aq) 1 mol L-1 Cu2+(aq)

(a) Write the cathode and anode reactions for this cell:

cathode \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ anode \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

[2 marks]

(b) On the diagram show the flow of electrons and the direction in which the anions move.

[2 marks]

1. A strong electrolyte is usually used as a salt bridge. Why is sodium carbonate solution, Na2CO3(aq), unsuitable?

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[2 marks]

(d) Both electrodes have a mass of 10.0 g at the start of the operation of the cell. After 10 minutes the mass of one electrode has changed to 10.56 g. What is mass of the other electrode?

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

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**Question 27 [8 marks]**

Information for two acids are as follows :

0.001 mol L-1 solution of HCO4 has a pH = 3 and 0.001 mol L‑1 solution of HCO has a pH = 5.3.

(a) Using information given above explain, with equations if possible, why NaCO4(aq) has a pH = 7 but NaCO(aq) has a pH > 7.

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[4 marks]

1. Again, using the given information, what chemicals could be used for a buffer solution?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ [1 mark]

(c) Explain what happens with the aid of an equation if HC (aq) is added to the buffer in (b).

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[3 marks]

**Question 28**  **[6 marks]**

The pH of pure water at 90oC is 6.13.

(a) What is the Kw, the equilibrium constant for water, at 90oC ? Show all working.

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

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[3 marks]

(b) Using this information determine whether the self ionization of water,

**H2O() ⇄ H+(aq) + OH-(aq),** is an exothermic or endothermic reaction. Show all working.

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[3 marks]

**Question 29 [8 marks]**

The products when the oxidants nitric acid, HNO3 and sulfuric acid, H2SO4 are reacted with copper metal and zinc depend on the concentration of the acids.

If the concentrated HNO3 acid is used a brown gas is obtained and if concentrated H2SO4 is used sulfur dioxide gas is produced.

(a) Write the half equation for concentrated nitric acid producing a brown gas.

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

[2 marks]

(b) Now write the full equation for the reaction between copper and concentrated nitric acid.

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[2 marks]

(c) In relation to the reduction potential for Cu2+ to Cu, what can you say about the reduction potential of concentrated nitric acid?

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

[1 mark]

(d) Write the full equation for the reaction between concentrated sulfuric acid and zinc.

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[3 marks]

**Question 30**   **[4 marks]**

Glycine is an amino acid with the formula H2**N**CH2**C**O**O**H

(a) Give the shape about the following highlighted atoms:

N \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

C \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

O \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

[3 marks]

(b) Write the formula of the species that is present when the glycine molecule is placed in a neutral solution (pH = 7).

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ [1 mark]

**Question 31** **[3 marks]**

The first four successive ionization energies (kJmol-1) for three elements X, Y and Z are listed below.

These elements could be Mg, Li, Ca or Na.

Place your choice for X, Y and Z into the last column of the table.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| element | 1st value | 2nd value | 3rd value | 4th value | answer |
| X | 738 | 1450 | 7733 | 10542 |  |
| Y | 598 | 1145 | 4912 | 6491 |  |
| Z | 496 | 4562 | 6910 | 9543 |  |

**Question 32 [4 marks]**

Draw the valence structures (electron dot diagrams) for the following, showing all valence electrons as either **‥** or  **–** .

|  |  |
| --- | --- |
| a) NH4CN | b) COC2 molecule |

**Question 33**  **[6 marks]**

When two compounds, X and Y, are reacted with Br2(aq) in the absence of light, the final product in both reactions was 1,1,2-tribromopropane.

(a) Draw the structure and give the IUPAC name of X and Y.

|  |  |  |
| --- | --- | --- |
| compound | structure | name |
| X |  |  |
| Y |  |  |

[4 marks]

(b) Draw a piece of the addition polymer polypropene giving three repeating units in your answer.

|  |
| --- |
|  |

[2 marks]

**Question 34** **[5 marks]**

When compounds **A** and **B** are reacted in the presence of concentrated sulfuric acid, a sweet smelling liquid **X** with formula **CH3CH2COOCH2CH3** is produced.

Compound **A** can also be oxidized using acidified potassium permanganate to give compound **C** that reacts with **Na2CO3(s)** to give a colourless gas.

(a) IUPAC Name of **X** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ [1 mark]

(b) Write the IUPAC name and the structure of compound **B**

Structure \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

[2 marks]

1. Write an ionic equation for reaction between compound **C** and **Na2CO3(s)**

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

[2 marks]

**Question 35 [12 marks]**

When chlorine gas is added to water, the following equilibrium is established:

**C2(g) + H2O() ⇄ HCO(aq) + H+(aq) + C-(aq) ΔH > 0**

1. Write the equilibrium constant expression for this reaction.

|  |
| --- |
|  |

[1 mark]

(b) Complete the following table. Answers should be given as “increase”, “decrease” or “no change”.

|  |  |  |
| --- | --- | --- |
| Change made to the equilibrium system | Effect on rate of forward reaction after equilibrium has been re-established | Effect on pH of solution after equilibrium has been re-established |
| Decrease the temperature of the system at constant volume. |  |  |
| Acidify the system by the addition of a small quantity of concentrated nitric acid |  |  |
| Addition of a small amount of silver nitrate solution |  |  |
| Decrease the pressure of C2(g) at constant temperature. |  |  |

[8 marks]

(c) When a change was made to the system, the K value increases.

(i) What change was made to the system? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ [1 mark]

(ii) Explain your answer

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

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[2 marks]

**Question 36 [4 marks]**

The boiling point of ethanol, CH3CH2OH is lower than the boiling point of butan-1-ol,

CH3CH2CH2CH2OH but the solubility of ethanol in water is higher than the solubility of butan-1-ol in water. Explain these facts.

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**END OF SECTION 2**

**Section 3: Extended answer 40% [80 Marks]**

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

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

Spare pages are included at the end of the 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 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 for this section is 70 minutes.

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**Question 37 [19 marks]**

There are numerous trends and patterns that occur in chemistry. Many of these can be explained using a knowledge of bonding.

(a) The electronegativity of an element was first proposed by Linus Pauling and can be used to explain some physical properties of substances.

(i) State how electronegativity changes down Group 1 and explain why this trend occurs.

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[3 marks]

(ii) State how electronegativity changes across Period 3 and explain why this trend occurs.

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(b) The boiling points of alcohols with the molecular formula C4H10O are 82°C, 99°C, 108°C and 118°C. The secondary alcohol has a boiling point of 99°C and has been added to the table for you. Complete the following table by identifying the class of each alcohol and assigning a boiling point.

|  |  |  |
| --- | --- | --- |
| **Structure of isomer** | **Class of alcohol** | **Boiling Point (°C)** |
|  | Secondary | 99 |
|  |  |  |
|  |  |  |
|  |  |  |

[10 marks]

(c) Explain why the isomers with the **lowest** and **highest** boiling points differ.

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[3 marks]

**Question 38 [16 marks]**

An alloy containing iron and manganese was analysed using the following method.

Step 1: 2.30 g of the alloy was first warmed with 100 mL of dilute nitric acid creating a solution of Fe3+ and Mn2+ ions.

Step 2: Excess sodium bismuthate, NaBiO3, was then added to the solution of Fe3+ and Mn2+ ions. When treated with sodium bismuthate, the bismuthate ion, BiO3**–**, forms Bi3+ and Mn2+ forms MnO4**–**.The resulting solution turned purple.

Step 3: Bismuthate ions were then removed . The solution produced in Step 2 was diluted to a total volume of 250 mL. Three 20.0 mL aliquots were titrated with 0.0920 mol L-1 of iron (II) sulphate (these aliquots were acidified). The resulting average titre of iron (II) sulfate with the solution was found to be 25.3 mL.

(a) What is the oxidation number of Bi in BiO3**–** ion?

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

[1 mark]

(b) Write a balanced half equation for the reduction process in Step 2.

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[2 marks]

(c) Write a balanced half equation for the oxidation process in Step 2.

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

[1 mark]

(d) Write the overall equation that occurs in Step 2.

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[2 marks]

(e) Write a balanced redox equation for the titration in Step 3 between Fe2+ and MnO4**–**.

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

[2 marks]

(f) Determine the % by mass of manganese in the alloy.

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[5 marks]

(g) Suggest why hydrochloric acid would have been an unsuitable choice for acidifying the solution in Step 3 of the method used. Give a suitable equation to justify your answer.

Explanation

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Equation

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[3 marks]

**Question 39 [16 marks]**

Guanine is one of the building blocks that makes up DNA. Guanine contains only carbon, nitrogen, oxygen and hydrogen. To determine the empirical formula of guanine a series of experiments were conducted.

Combustion Analysis

Combustion of 6.15 g of guanine produced 8.95 g of carbon dioxide.

In a separate combustion reaction, a 5.20 g mass of guanine produced 1.55 g of water.

Conversion of Nitrogen to Ammonia

A further sample of 4.00 g of guanine was boiled with an excess of sulfuric acid and then neutralised with sodium hydroxide. This converts all the nitrogen in guanine to ammonia.

Volumetric Analysis

The resulting solution was titrated with 5.91 mol L-1 hydrochloric acid until the solution was neutralised. Using a suitable indicator for the reaction, the titre was found to be 22.4 mL.

(a) Determine the empirical formula of guanine.

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[9 marks]

(b) When vapourised at 300°C at a pressure of 111.1 kPa, a 2.65 g sample of guanine was found to occupy a 752 mL volume. Determine the molecular mass and then the molecular formula for guanine.

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[3 marks]

(c) Amino acids are the building blocks of substances called peptides. The structure for alanine is shown below.



Alanine

Draw the structure of the peptide formed when three alanine molecules react.

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[2 marks]

(ii) Draw the structure of alanine in a high pH solution.

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|  |

[2 marks]

**Question 40 [14 marks]**

An industrial method for the production of hydrogen cyanide (HCN) occurs by the reaction of carbon monoxide with ammonia gas in the presence of platinum:

**2 CH4 (g) + 2 NH3 (g) + 3 O2 (g)** ⇄ **2 HCN (g) + 6 H2O (g) ΔH = -481 kJ**

(a) Discuss how you could change the following conditions of this reaction to achieve the maximum yield and rate of production of hydrogen cyanide and explain your choices using appropriate theories.

(i) Temperature

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[4 marks]

(ii) Pressure

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[3 marks]

(iii) Catalyst

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[2 marks]

(b) Hydrogen cyanide has a molar mass of 27.03 g mol-1 and boils at 26.0°C. Nitrogen gas has a molar mass of 28.02 g mol-1 and boils at -196°C. Account for the difference in boiling points.

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[5 marks]

**Question 41 [15 marks]**

29.0 mL of 0.312 mol L-1 sodium phosphate and 29.0 mL of 0.438 mol L-1 cobalt (II) chloride solutions were mixed together. A precipitate was formed. (Assume volumes are additive).

(a) Write an ionic equation for the reaction.

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[2 marks]

(b) Determine the limiting reagent for the reaction. Justify your answer with appropriate calculations.

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[5 marks]

(c) Determine the dry mass, in grams, of the precipitate formed.

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[2 marks]

(d) Using the information from parts (a) and (b) give a full observation for the chemical reaction.

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[2 marks]

(e) Determine the concentrations, in mol L-1, of the ions remaining in solution.

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[4 marks]

**END OF EXAMINATION**