

### Year 12 Chemistry

**Trial Examination 2011**

**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 |  | 6 | 38 |  | 13 | Section 1 |  | 50 |
|  |  | 27 |  | 3 | 39 |  | 20 | Section 2 |  | 70 |
|  |  | 28 |  | 6 | 40 |  | 21 | Section 3 |  | 80 |
|  |  | 29 |  | 6 | 41 |  | 15 | Total |  | 200 |
|  |  | 30 |  | 6 | 42 |  | 11 |  |  |  |
|  |  | 31 |  | 8 |  |  |  | **Total** |  | **%** |
|  |  | 32 |  | 10 |  |  |  |  |  |  |
|  |  | 33 |  | 5 |  |  |  |  |  |  |
|  |  | 34 |  | 3 |  |  |  |  |  |  |
|  |  | 35 |  | 7 |  |  |  |  |  |  |
|  |  | 36 |  | 6 |  |  |  |  |  |  |
|  |  | 37 |  | 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 | 12 | 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 answers in the Question/ Answer Booklet.

2. When calculating numerical answers, show your working or reasoning clearly unless instructed otherwise

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 to use the space to continue an answer, indicate in the original answer space where an answer is to be continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

**Section 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 of the following has a different number of electrons to the other three?

A. O3

B. Sc3+

C. C2H6

D. CH3F

**Questions 2 and 3 refer to the following set of successive ionisation energies of the four elements W,X,Y and Z**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Ionisation energy  kJmol–1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| W | 494 | 4560 | 6940 | 9540 | 13400 | 16600 | 20100 | 25600 | 28900 |
| X | 2080 | 3950 | 6150 | 9290 | 12100 | 15200 | 20000 | 23000 | 115000 |
| Y | 519 | 7300 | 11800 |  |  |  |  |  |  |
| Z | 1090 | 2350 | 4610 | 6220 | 37800 | 47000 |  |  |  |

2. Two of these four elements are in the same group of the periodic table. Which one is lower down in the group?

A. Element W

B. Element X

C Element Y

D Element Z

3. Which of the following would most likely have the lowest melting point?

1. Element Y
2. Element X
3. Element Z
4. The oxide of W

**Questions 4 and 5 refer to the following four substances.**

|  |  |  |
| --- | --- | --- |
|  | Name | Structure |
| I | hydroxylamine |  |
| II | methanol |  |
| III | methoxymethane |  |
| IV | ethyl ethanoate |  |

4. In which of the above substances would you expect hydrogen bonding to be present between their molecules?

A. All of them

B. I, II and III

C. I and II

D. II and IV

5. Which is the only one of the above molecules that has a trigonal planar arrangement of atoms around one of the atoms in the molecule?

A. hydroxylamine

B. methanol

C. methoxymethane

D. ethyl ethanoate

6. Consider the reaction between 1.00 g of lithium carbonate powder and 100 mL of

0.200 molL–1 ethanoic acid. Which of the following changes would result in an increase in the initial rate of reaction?

1. Change the lithium carbonate powder to a single lump.
2. Change from ethanoic acid to hydrochloric acid.
3. Change from 100mL of ethanoic acid to 200mL of ethanoic acid.
4. Increase the pressure.

7. When solid silver chromate is added to water, the following equilibrium is established:

Ag2CrO4(s) ⇄ 2 Ag+(aq) + CrO42–(aq)

A small quantity of soluble **sodium chromate** solid is added to the solution. Assuming there is no change in the volume of the system, which of the following statements is correct?

A. The concentration of CrO42–(aq) will increase and the concentration of Ag+(aq) will not change.

B. The concentration of CrO42–(aq) will decrease and the concentration of Ag+(aq) will increase.

C. The concentration of CrO42–(aq) will increase and the concentration of Ag+(aq) will decrease.

D. The concentration of CrO42–(aq) and Ag+(aq) will not change.

8. If solid calcium carbonate is heated in a sealed container, the following equilibrium is established at 500°C and 600 kPa pressure:

CaCO3(s) ⇄ CaO(s) + CO2(g) ΔH = + 178 kJ mol–1

Now consider the following actions:

I Add more CO2(g) to the system

II Add more CaCO3 to the system

III Decrease the volume of the system

IV Increase the temperature of the system

One or more of these actions lead to a change in CO2(g) concentration (after equilibrium is re-established). Which statement below is true?

A. All actions lead to a change in CO2(g) concentration

B. Only II, III and IV lead to a change in CO2(g) concentration

C. Only III and IV lead to a change in CO2(g) concentration

D. Only IV leads to a change in CO2(g) concentration

**Questions 9 and 10 refer to the following equilibrium reaction;**

4 NH3(g) + 5 O2(g) ⇄ 4 NO(g) + 6 H2O(g) ΔH = – 42 kJ

The graph below represents changes in the concentrations of NH3 and NO over time:

|  |  |
| --- | --- |
| **Concentration of gases** | NH3  NO  NO NH3 |
|  | 0 10 20 30 40 |
|  | **Time (minutes)** |

9. At the 20 minute mark, what changes could have been made to the system to produce the effect shown by the graph?

1. The temperature of the system is decreased
2. More O2 gas is added
3. Some H2O(g) is removed

IV. The volume of the container is decreased

1. I, II and III
2. II, III and IV
3. I, III and IV
4. I, II and IV

10. During the time between 20 and 30 minutes, which of the following statements is true about the forward reaction?

1. It is faster than the backwards reaction and is slowing down.
2. It is faster than the backwards reaction and is speeding up.
3. It is slower than the backwards reaction and is speeding up.
4. It is slower than the backwards reaction and is slowing down.

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

A. pentane > propanone > propan-1-ol

B. propanone > pentane > propan-1-ol

C. propan-1-ol > pentane > propanone

D. propan-1-ol > propanone > pentane

12. Which of the following substances does not exist?

A. HCHO

B. HOOCCOOH

C. (CH3)3COH

D. H3CCH2CHCH3

13. Which of the following pairs of compounds are isomers?

I CH3OOCH and CH3COOH

II Cl H Cl Br

| | | |

H−C − C−H and H−C − C−H

| | | |

H Br H H

III CH3CH2CH2CHCH3 and CH3CHCH2CH2CH3

| |

OH OH

A. I only

B. I and II

C. II and III

D. All of the above

14. Which substances could be reacted together to form this compound?



A. methanol and acidified potassium dichromate

B. methanal and acidified potassium permanganate

C. methanoic acid and methanol

D. ethyl methanoate and methanol

15. Which of the following reactants are capable of forming a condensation polymer under suitable conditions?

A. HOCH2CH2CH2CH2CH2CH2CH2COOH

H H

\ /

B. C=C

/ \

H Cl

H H

\ /

C. C=C

/ \

H C=O

I

O

\

CH3

D. HOOC(CH2)7COOH and HOOC(CH2)3COOH

16. Which of the following statements is true?

A. The pH of 0.100 molL–1 hydrochloric acid is the same as 0.100 molL–1 ethanoic acid.

B. Weak acids and weak bases do not react with each other.

C. Water can act as an acid and a base.

D. Ammonia is a better proton donor than acceptor.

17. A dilute solution of ammonia (in the conical flask) was titrated against hydrochloric acid (in the burette) using phenolphthalein as the indicator. Which of the following statements is true?

A. The end point occurs before the equivalence point.

B. The end point occurs at the equivalence point.

C. The end point occurs after the equivalence point.

D. There is no end point because the wrong indicator is being used.

18 When the pH of a solution changes from 9 to 12 the

A. hydroxide ion concentration increases by a factor of 3.

B. hydrogen ion concentration increases by a factor of 3.

C. hydroxide ion concentration decreases by a factor of 1000.

D. hydrogen ion concentration decreases by a factor of 1000.

19. Consider the equation: HSO4–(aq) + OH–(aq) ⇄ SO42−(aq) + H2O(l)

The Brønsted-Lowry acids in this equation are:

1. HSO4−(aq) and SO42−(aq
2. OH−(aq) and SO42−(aq)
3. OH−(aq) and H2O(l)
4. HSO4−(aq) and H2O(l)

20. A chemist measures the pH of four 1.00 x 10–2 molL–1 acid solutions, and obtains the following results. Which experimental result must be incorrect?

|  |  |  |
| --- | --- | --- |
| Experiment | Solution | pH |
| A. | CH3COOH | 3.4 |
| B. | H3PO4 | 2.2 |
| C | HNO3 | 2.0 |
| D. | H2SO4 | 1.4 |

21. An ore of titanium is Na2TiO3. The ore was dissolved in sulfuric acid and was then oxidised with KMnO4 solution. The titanium in the final solution could be present as:

A. Ti4+

B. Ti3+

C. Ti5+

D. Ti

22. Which of the following are redox reactions?

I. The reaction of magnesium metal with hydrochloric acid

II. The reaction of magnesium metal with oxygen

III. The reaction of magnesium oxide and hydrochloric acid

IV. The reaction of magnesium carbonate with hydrochloric acid

A. I, II and III

B. I, II and IV

C. I and II

D. II only

23. A metal X in a solution of its ions was connected up to a Fe/Fe2+(aq) half cell and the resultant voltage was recorded. A value of 1.94 V was obtained. Which is a possible identity of metal X?

A. Al

B. Au

C. Na

D. Ag

24. When using acidified potassium permanganate, the acid used is sulfuric acid rather than hydrochloric acid. The reason for this is:

A. Sulfuric acid is diprotic and hence gives a higher concentration of hydrogen ions.

B. The chloride ions in hydrochloric acid are likely to form a precipitate with other ions in the redox titration.

C. Acidified permanganate ions can oxidise the chloride ions in the hydrochloric acid to chlorine.

D. Sulfuric acid is a primary standard whilst hydrochloric acid is not.

25. Disproportionation reactions are ones in which an element is both oxidised and reduced. Which of the following are disproportionation reactions?

I. 2 H2O2 🡪 2 H2O + O2

II. 2 Cu+ 🡪 Cu + Cu2+

III. 2 NO2 + H2O 🡪 HNO3 + HNO2

IV. 3 Br2 + 3 H2O 🡪 BrO3**–** + 5 Br**–** + 6 H+

A. I, II and III

B. II, III and IV

C. I, II and IV

D. All of them

**END OF SECTION ONE**

**Section 2: Short Answer 35% [70 marks]**

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

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

* Planning: If you use the spare pages for planning, indicate this clearly at the top of the page
* 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 for this section is 60 minutes.

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**Question 26 [6 marks]**

Write equations for the reaction that occurs in each of the following procedures.

If no reaction occurs, write ‘no reaction'.

In each case describe what you would observe, including any

* colour change
* odour
* precipitate (give the colour)
* Gas evolutions (state the colour or describe as colourless)

If a reaction occurs but the change is not observable, you should state this.

(a) 1 mol L–1 iron (III) nitrate solution is added to a 1 mol L–1 sodium iodide solution.

[3 marks]

Equation\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Observation\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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(b) Sodium sulfide solution is added to excess copper (II) chloride solution. [3 marks]

Equation\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Question 27 [3 marks]**

Butane and propan-1-ol have similar molar masses. Explain, in terms of intermolecular forces, which of the two compounds will have the higher boiling point.

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**Question 28 [6 marks]**

(a) What **chemical test** and **observations** could be used to distinguish between the following:

(i) methylpropan-2-ol and propanoic acid. [3 marks]

Test:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Observation with methylpropan-2-ol \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Observation with propanoic acid \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(ii) Zinc and Chromium [3 marks]

Test:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Observation with Zn\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Observation with Cr \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 29 [6 marks]**

Draw electron-dot diagrams showing the arrangement of all valence electrons in the following chemical species. Describe the shape of each (eg: linear/bent/etc)

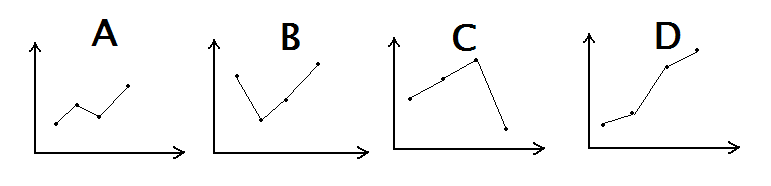
|  |  |
| --- | --- |
| **NaNO3**  **Shape of Anion** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | **H2SO4**  **Shape around the S atom** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

**Question 30 [6 marks]**

(a) For each of the unlabelled graphs below select which one best represents the expected

plots for: [3 marks]

1. The boiling points of the hydrides of group 16. \_\_\_\_\_\_\_\_\_
2. The melting points of elements with Atomic numbers 12, 13, 14, 15. \_\_\_\_\_\_\_\_
3. The first four successive Ionisation Energy values for a group 2 element. \_\_\_\_\_\_\_



(b) Explain your choice for (iii). [3 marks]

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

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**Question 31 [8 marks]**

Phenolphthalein is a diprotic acid molecule and has two different equilibrium situations which are sensitive to concentrations of OH– (aq). In pH range less than or equal to 8.3 the fully hydrogenated form is in such high concentrations and there is no evidence of the first ionisation step forming H3O+(aq) and a pink coloured ion.

If the phenolphthalein molecule is written as H2PhTh, then the equilibrium equation for the hydrolysis of phenolphthalein could be written as

H2PhTh + H2O ⇄ HPhTh– (aq) + H3O+(aq) ΔH = + kJ

colourless pink

(a) From the information given above, is the K value for the equation as written going to be high or low? Explain your answer. [2 marks]

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

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(b) The following changes are imposed on a solution of phenolphthalein at equilibrium.

Each change is made to a separate test tube and equilibrium is re-established. Complete the table below, indicating the effect on the concentration of HPhTh–(aq) and the value of K. Use terms ‘increase’, ‘decrease’ or ‘no change’.

Also describe what you would observe as equilibrium is re-established in the system.

[6 marks]

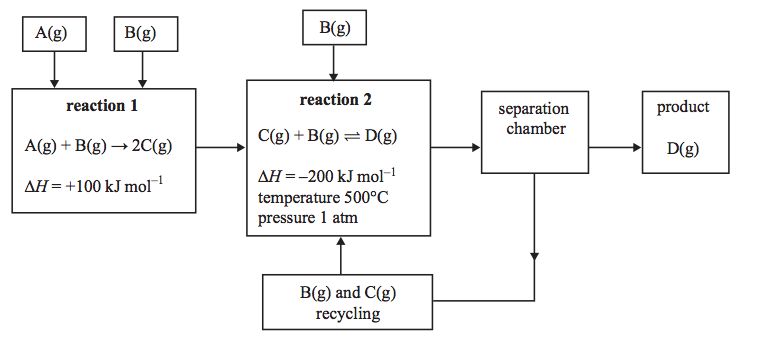
|  |  |  |  |
| --- | --- | --- | --- |
| Imposed change | Effect on  [HPhTh–] (aq) | Effect on K | Observation |
| HCl(g) is bubbled  through the solution |  |  |  |
| The solution is heated |  |  |  |

**Question 32 [10 marks]**

A particular industrial process involves the steps shown on the diagram.

Reaction 1 proceeds to completion but reaction 2 reaches equilibrium and has a high Activation energy.

The product of the industrial process, **D**, passes through a membrane in the separation chamber which is impermeable (resistant) to **B** and **C**.



(a) D is removed from the system in the separation chamber at t1.

(i) Sketch graphs on the axes below showing how this affect the rates of the forward

and reverse reactions. Continue your graph until equilibrium has been

re-established at t2.

[3 marks]

Forward

Reverse

Rate

t1 t2 Time

(ii) Explain the changes in rates for the forward and reverse reactions. [4 marks]

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(b) In practice the industrial process gives a poor yield of product **D**. As the equilibrium mixture of reaction 2 moves into the separation chamber, what changes would you make to the conditions to increase the yield of **D?**

(No explanations are required) [3 marks]

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**Question 33 [5 marks]**

What is the pH of a mixture resulting from the addition of 500 ml of 0.10 molL–1 NaOH and

750 ml of 0.050 molL–1 HCl?

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**Question 34 [3 marks]**

The hydrogen phosphate ion, HPO42–(aq), is an unusual ion in that it can stabilise solutions by reacting with both small acid changes and small alkaline changes and help keep the pH at a near neutral position.

(a) What is the term used to describe this action of the hydrogen phosphate ion?

[1 mark]

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(b) Write equations showing how this ion responds to a small addition of: [2 marks]

(i) An acid:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(ii) A Base:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Question 35 [7 marks]**

Consider the electrochemical below:



(a) Write the half-equation for the reaction which occurs at the positive electrode. [1 mark]

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(b) Write the equation for the overall redox equation in the cell. [1 mark]

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(c) Calculate the EMF (voltage) of the cell at standard conditions. [1 mark]

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(d) Both the anode and cathode have a mass of 5.00 g before they are connected in the cell. The electrodes are connected for 10 minutes and one of the electrodes was found to have a mass of 7.50 g when reweighed. What is the mass of the other electrode after this time?

[4 marks]

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**Question 36 [6 marks]**

Iron is often coated with other metals to prevent corrosion. “Tin cans” are iron coated with tin and “galvanized iron roofing steel” is iron coated with zinc.

What will happen to the iron when, after a period of time, the tin can and roofing steel are scratched so that the iron is exposed to the moist atmosphere? Using E0, values explain your observations.

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**Question 37 [4 marks]**

Below is a newly developed amino acid that has the potential for development of an anti- inflammatory drug.

(a) Explain why it is considered to be an amino acid? [1 mark]

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(b) The molecule above is not an α-amino acid. In the space below draw the molecule as an α-amino acid. [1 mark]

(c)

(i) Draw the structural formula of the conjugate base of the original amino acid.

[1 mark]

(ii) Complete the reaction below to show what happens when hydrochloric acid is added to the amino acid. [1 mark]

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**END OF SECTION TWO**

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

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

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 38 [13 marks]**

Ground water contains a number of impurities that must be removed during treatment for it to be suitable for drinking. Soluble iron (II) and manganese (II) compounds are often found in ground water. Although they are not toxic they do contribute to unpleasant odours, taste and colour.

One method of the removal of iron (II), in the form of iron (II) hydrogencarbonate, is to add chlorine and calcium hydrogencarbonate. This causes the iron (II) to oxidise to iron (III) hydroxide which precipitates out and can be filtered off. The other products are calcium chloride and carbon dioxide.

The balanced equation for the reaction is:

2 Fe(HCO3)2(aq) + Cl2(g) + Ca(HCO3)2(aq) 🡪 2 Fe(OH)3(s) + CaCl2(aq) + 6 CO2(g)

(a) Predict the observations for this reaction. [3 marks]

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A 1000.0 kg sample of ground water containing 45.6 ppm (mg solute/kg solution) of iron (II) hydrogencarbonate is treated by the addition of 3.22 L of chlorine gas at 25oC and 103.2 kPa and excess calcium hydrogencarbonate.

(b) Determine the limiting reagent of this reaction. [5 marks]

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(c) Calculate the mass of iron (III) hydroxide that is produced in this reaction. [2 marks]

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(d) Calculate the mass of excess reagent remaining at the end of the reaction. [3 marks]

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**Question 39 [20 marks]**

You have been given a bottle of wine for testing the acid content and a standardised sodium hydroxide solution. Assume that the acid is present as tartaric acid, a diprotic weak acid. You place the standard solution in the burette.

(a) For the equipment listed below, indicate what each should be rinsed with. [4 marks]

|  |  |
| --- | --- |
| Equipment | Rinsed with |
| Stock bottle to store NaOH solution |  |
| Conical flask |  |
| Pipette |  |
| Burette |  |

(b) Which of these two given indicators would be an appropriate indicator for this titration? Explain your choice. [3 marks]

Thymol blue: endpoint range 8.0 – 9.6 colours: yellow (acidic) – blue (basic)

Bromophenol blue: endpoint range 3.0 – 4.6 colours: yellow (acidic) – violet (basic)

Indicator choice:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Explanation:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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(c) The sodium hydroxide needed to be standardised before it can be titrated with the wine since it cannot be used as a primary standard. [4 marks]

List 3 characteristics that make a substance suitable to be used as primary standard?

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Why is sodium hydroxide unsuitable as a primary standard?

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(d) The wine was diluted before it was titrated with the NaOH solution. 10 mL of wine was added to 100 mL volumetric flask and the solution made up to 100 mL. 25.0 mL aliquots of the diluted wine were then titrated against the standard 0.102 mol L–1 NaOH solution. The burette readings are as follows:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 |
| Final volume, mL | 22.56 | 43.22 | 22.02 | 42.73 |
| Initial volume, mL | 2.11 | 22.56 | 1.40 | 22.02 |
| Titre used, mL |  |  |  |  |

1. Complete the table and calculate the average titre. [2 marks]

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1. Calculate the concentration in mol L–1 of the tartaric acid in [4 marks]

* the diluted wine and then in
* the original wine.

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1. Assuming the density of the wine is 1.05 g mL–1, calculate the percentage by mass of the tartaric acid in the wine.

The molar mass of tartaric acid is 150.0 g mol–1. [3 marks]

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**Question 40 [21 marks]**

Propan-1-ol and propene are extremely useful carbon compounds used in industry to make ropes, carpets, fuel oils etc. The production of propan-1-ol can be achieved two ways:

* the selective addition of water to propene and
* the hydroformylation of ethene to propanal using CO and H2 and then the hydrogenation of propanal to propan-1-ol.

(a) Write the equation for the reaction between propene and water to produce propan-1-ol in the presence of phosphoric acid. All reactants and products are in the gas phase. [1 mark]

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(b) There is a possibility of another alcohol being formed in (a) above, name this alcohol. [1 mark]

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(c) Write a balanced equation for the reaction between ethene and CO and H2 to produce propanal. [1 mark]

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(d) Write a balanced equation for the reaction between propanal and hydrogen to give propan-1-ol. [1 mark]

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(e) Propene is used by Shell to make the addition polymer polypropene which is used to make carpets and ropes. Draw a piece of polypropene showing at least three monomer units. [2 marks]

(f) If the equilibrium reaction in (a) above is exothermic, explain what conditions of temperature and pressure you would employ to optimise the production of propan-1-ol. The phosphoric acid must also be mentioned in your discussion. [7 marks]

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

(g) The propan-1-ol produced can be oxidised with excess acidified potassium permanganate to produce propanoic acid which can then be used in the production of several esters.

Write the two-half equations for the reaction between propan-1-ol and acidified potassium permanganate to make propanoic acid. [5 marks]

Reduction reaction:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Oxidation reaction: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Full Redox reaction:

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

(h) The ester ethyl propanoate is used as a fragrance in several products. [3 marks]

1. What compound must be added to propanoic acid to form this ester? \_\_\_\_\_\_\_\_\_
2. Draw the full structure of this ester.

**Question 41 [15 marks]**

An old drum of pesticide has been found on a farm. Elemental analysis of this pesticide shows the presence of carbon, hydrogen, phosphorus and oxygen. A 5.21 g sample of the pesticide produces

6.32 g of carbon dioxide and 3.23 g of water when combusted completely in excess oxygen.

A second sample, 3.15 g of the pesticide is treated with nitric acid to convert all the phosphorus to phosphate ions. The resulting solution is treated with excess calcium nitrate solution to produce 3.37 g of calcium phosphate.

(a) Determine the empirical formula of the pesticide. [11 marks]

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(b) At 25oC and 110.1 kPa, 1.84 g of this pesticide has a volume 142.7 mL in the gaseous phase. Determine the molar mass of this pesticide. [2 marks]

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(c) What is the molecular formula of the pesticide? [2 marks]

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**Question 42 [11 marks]**

Using Group I elements and Period 3 elements discuss and explain the variation in the following properties of the elements:

1. Melting Points [7 marks]
2. Electronegativity [4 marks]

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**END OF EXAMINATION**

**Additional working space**  
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