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Student Number

2002
Trial Higher School Certificate
Examination

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board-approved calculators may be used
- Write using blue or black pen
- Draw diagrams using pencil
- A Data Sheet and Periodic Table are provided at the back of this paper.

Section I

 Pages 3 – 15

Total marks (75)

This section has two parts, Part A and Part B

Part A

Total marks (15) Pages 3 - 7

- Attempt questions 1 – 15
- Allow about 30 minutes for this part

Part B

Total marks (60) Pages 8 - 15

- Attempt questions 16 – 27
- Allow about 1 hour and 45 minutes for this part.

Section II

Total marks (25) Pages 16-17

- Attempt all parts of this question
- Allow about 45 minutes for this section.

Section I

Total marks (75)

Part A

Total marks (15)

Attempt questions 1 – 15

Allow about 30 minutes for this part

Use the multiple-choice answer sheet.

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

A ☐ B ☒ C ☐ D ☐

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ☒ B ☒ C ☐ D ☐

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows:

A ☒ B ☒ C ☐ D ☐
correct

- 1 $\text{HCO}_3^- (\text{aq})$ is an amphoteric species as shown by the two equations



Choose the conjugate base of $\text{HCO}_3^- (\text{aq})$ from the list given below.

- A OH^-
- B H_2CO_3
- C H_2O
- D CO_3^{2-}

- 2 Two indicators, Methyl Orange and Orange IV were added to solutions of varying concentrations of hydrochloric acid. The colours observed and the concentrations of H^+ ions are listed below.

$[\text{H}^+] (\text{mol L}^{-1})$	Orange IV	Methyl Orange
0.10	pink	red
0.010	pink	red
0.0010	pale yellow	red
0.00010	pale yellow	orange
0.000010	orange	yellow
0.0000010	orange	yellow

The two indicators were used to test a 0.10 mol L^{-1} solution of ethanoic acid. The following results were obtained:

	Orange IV	Methyl Orange
0.10 mol L^{-1} ethanoic acid	pale yellow	red

Which of the following would be the correct value for the pH of the solution?

- A 1
- B 2
- C 3
- D 4

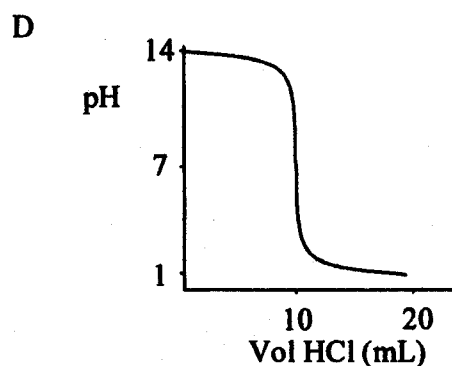
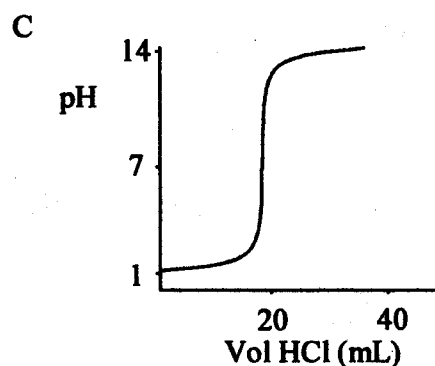
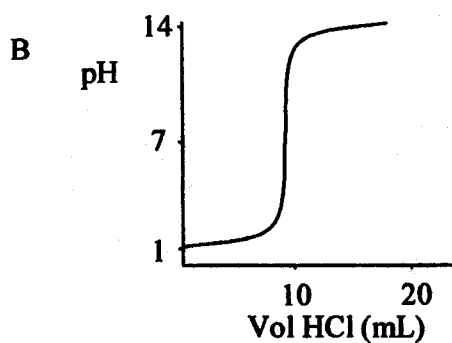
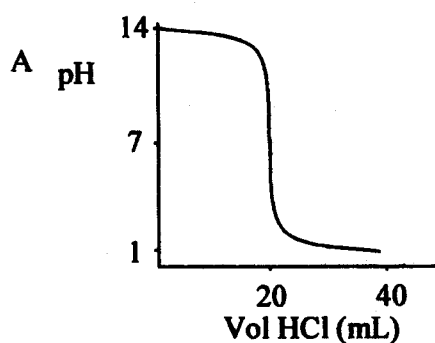
- 3 Which equation shows a species acting as a Lewis acid, but not a Bronsted-Lowry acid?

- A $\text{H}_2\text{S} + \text{CN}^- \rightarrow \text{HCN} + \text{HS}^-$
- B $\text{H}_2\text{S} + \text{NH}_3 \rightarrow \text{HS}^- + \text{NH}_4^+$
- C $\text{CO}_3^{2-} + \text{H}_3\text{O}^+ \rightarrow \text{HCO}_3^- + \text{H}_2\text{O}$
- D $\text{BF}_3 + \text{F}^- \rightarrow \text{BF}_4^-$

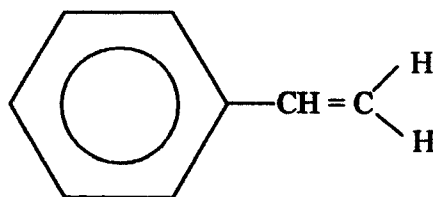
4 Which of the following dissolves in water to form a basic solution?

- A potassium citrate
- B sodium nitrate
- C ammonium chloride
- D aluminium sulfate

5 A 20 mL sample of 0.10 mol L^{-1} potassium hydroxide is titrated with 0.20 mol L^{-1} hydrochloric acid. Which of the following pH curves best shows the progress of the titration?



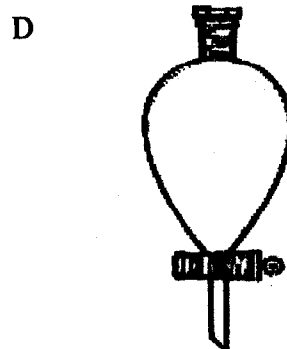
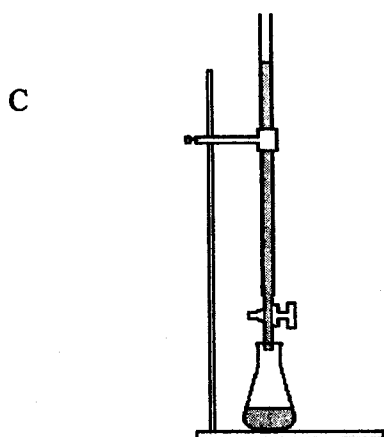
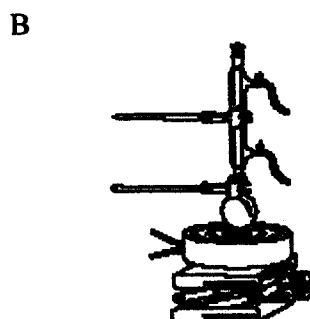
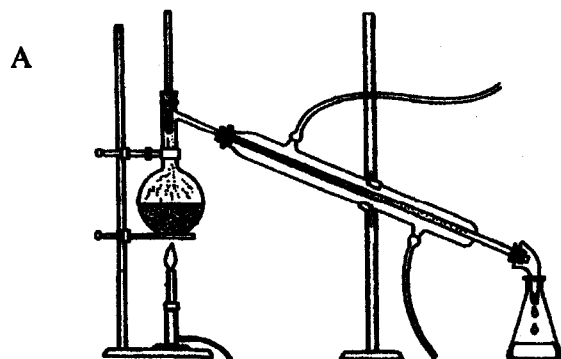
6 A systematic name for the following molecule is ethyl benzene.



Select its common name from the list below.

- A styrene
- B acrylonitrile
- C vinyl chloride
- D propylene

- 7 Which of the following apparatus could be used to isolate almost pure ethanol from a mixture produced by fermentation of glucose solution?



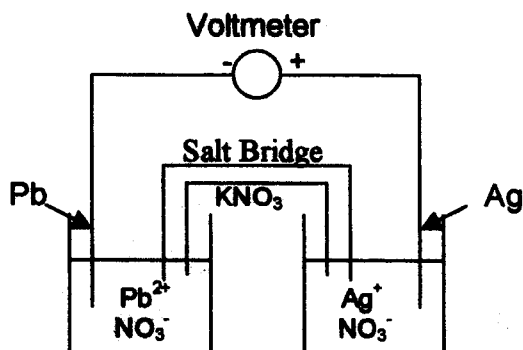
- 8 Phosphorus-32 undergoes β decay to achieve greater nuclear stability. Which of the following atoms would be formed in this process?

- A aluminium -28
- B phosphorus -31
- C sulfur-31
- D sulfur-32

- 9 Bromine liquid is added to each of two test tubes, one contains cyclohexane, the other cyclohexene. Choose one of the following statements which best relates to this experiment.

- A The test tube with cyclohexane turns brown in sunlight.
- B Cyclohexene undergoes an addition reaction with bromine.
- C Cyclohexane is more reactive because of its bonding.
- D Cyclohexene turns bromine brown immediately.

- 10 Study the diagram of the simple galvanic cell shown below.



Which of the following statements applies to this cell?

- A the lead ions are being oxidised
- B the electron flow is from the silver electrode to the lead electrode
- C the lead electrode is the anode
- D the silver electrode is the site of oxidation.

The next two questions refer to the following information.

The Haber process is well known for the industrial production of ammonia. The process can be summarised by the equation:



- 11 From this information, which conditions best favour the yield of ammonia ?
- A low temperature and high pressure
 - B low temperature and low pressure
 - C high temperature and low pressure
 - D high temperature and high pressure
- 12 What is the effect of increasing the temperature of the reaction for the rate of ammonia production in the Haber process ?
- A not affected as according to Le Chatelier's Principle the equilibrium will adjust to the change of temperature
 - B increase because the kinetic energy of the molecules will increase
 - C decrease because the reaction is exothermic
 - D increase briefly, then decrease as the equilibrium shifts

- 13 An iron oxide/aluminium oxide catalyst is used in the Haber process. What is the function of this catalyst?
- A To increase the yield of ammonia produced in the reaction
 - B To increase the rate of the ammonia forming reaction
 - C To reduce the pressure required for complete reaction
 - D To reduce the reaction temperature required
- 14 Solution X is believed to be calcium chloride. A flame test of the solution X gives a bright orange/red colour and adding 2.0 M $\text{HNO}_{3(\text{aq})}$ to solution X produces small bubbles of a colourless gas which is identified as carbon dioxide.
From these results, what is the possible composition of solution X ?
- A calcium ions and chloride ions
 - B calcium ions but not chloride ions
 - C chloride ions but not calcium ions
 - D neither calcium nor chloride ions
- 15 Residents of a local community around a paint factory were concerned that the factory may be disposing of small amounts of lead waste into the local waterways. Which of the following is the most sensitive and efficient method of comparing the concentration of lead ions in water from the factory with that of uncontaminated water ?
- A volumetric analysis with chloride ions
 - B gravimetric analysis with precipitates of lead sulfate
 - C distillation to determine the percentage of lead present
 - D atomic absorption spectroscopy.

Section 1 (continued)

Part B – 60 marks

Attempt Questions 16 – 27

Answer the questions in the spaces provided.

Show all relevant working in questions involving calculations.

Question 16 (6 marks)

A student placed a 0.5g strip of magnesium ribbon in 100 mL of

- (i) 0.10 mol L⁻¹ ethanoic acid
- (ii) 0.10 mol L⁻¹ sulfuric acid.

Compare the chemistry of the above two reactions in terms of the strength of the acid, rate of reaction and volume of gas formed. Use equations in your answer.

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Question 17 (3 marks)

The hydrogen phosphate (HPO_4^{2-} , H_2PO_4^-) buffer system helps maintain the optimum pH in the blood. Describe how the buffer system reacts if the pH of the blood suddenly drops. Include relevant equations in your answer.

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Question 18 (7 marks)

Marks

In a metal sulfide roaster, the ore is heated in air and converted to a metal oxide, releasing sulfur dioxide.

- (i) Write the balanced symbol equation for the roasting of zinc sulfide in air. 1

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- (ii) If one tonne (1000 kg) of zinc sulfide was roasted, what volume of sulfur dioxide would be produced at 0 °C and 101.3 kPa. 2

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- (iii) Sulfur dioxide acts as a Lewis acid during the formation of acid rain. Define a Lewis acid. 1

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- (iv) Outline the formation and describe two effects of this acid rain produced as a by-product of the sulfide ore roasting process. 3

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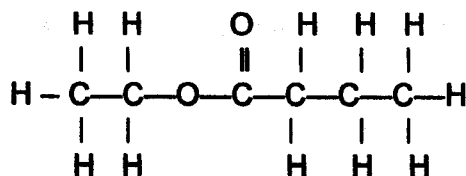
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Question 19 (4 marks)**Marks**

A compound A of melting point 163 °C, was refluxed with compound B of Boiling point 78 °C, in the presence of a few drops of concentrated sulfuric acid. The ester formed had the following structural formula:



- (i) Draw and name B. Justify your choice.

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- (ii) What is the purpose of the sulfuric acid?

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Question 20 (5 marks)

The biopolymer cellulose may be used on a large scale in the future as a raw material to make petrochemicals and plastics.

- (i) Why would cellulose be a good raw material to build petrochemicals?

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- (ii) Cellulose is a condensation polymer. Explain the meaning of the term 'condensation polymer' and name the monomer from which cellulose is formed.

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- (iii) Rayon and celluloid are polymers derived from modified cellulose. Much research is directed at making new plastics and fibres from biopolymers. What should be two advantages of these biopolymers?

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Question 21 (7 marks)**Marks**

Ethanol can be used as a fuel. One way to make ethanol is by fermentation of sugars.

- (i) Write a balanced equation for the fermentation of a sugar

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- (i) The heat of combustion of ethanol can be determined experimentally in the laboratory. A spirit burner containing ethanol was used to heat 250g of water in a metal beaker. The water temperature rose from 12°C to 20°C. The spirit burner lost 0.92g mass, due to ethanol burning. Calculate the experimental value for the molar heat of combustion, given that the specific heat capacity for water is 4.18 J/g/°C.

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- (ii) Assess the potential of ethanol as an alternative fuel and discuss the advantages and disadvantages of its use.

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Question 22 (2 marks)

In the industrial use of electrolysis for refining a named metal, identify

- (i) the name of the metal and the electrolyte used

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- (ii) one conditions under which the electrolysis must occur.

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Question 23 (6 marks)

Marks

Choose one cell from the following list: button cell, mercury cell, vanadium redox cell, lithium cell, liquid junction photovoltaic cell (Gratzel cell).

- (i) List the anode and cathode reactions for this cell.

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- (ii) Describe the relative cost, practicality and environmental impact of your named cell when compared to either a dry cell or a lead acid battery.

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Question 24 (2 marks)

Describe a chemical test used to identify the presence of the following species in a water sample.

- (i) sulfate ions

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- (ii) iron (II) ions

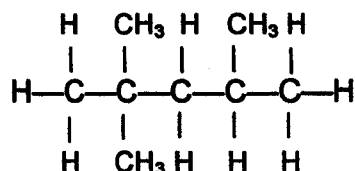
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Question 25 (5 marks)**Marks**

Most car engines burn petrol (2,2,4-trimethylpentane). When car engines are well-tuned complete combustion of the petrol occurs, but at times when the engine is running poorly the combustion process is incomplete.

The structural formula for 2,2,4-trimethylpentane is :



- (a) What is the
- | | |
|------|--|
| (i) | molecular formula and |
| (ii) | molar mass of 2,2,4-trimethylpentane ? |

(i) 1

(ii) 1

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- (b) Explain using equations why chemists need to monitor car engines because 3
of the products of incomplete combustion.

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Question 26 (6 marks)

Marks

Ozone is produced in both the upper and lower atmosphere as a result of the reaction between oxygen molecules and an oxygen atom (free radical). The ozone produced is often regarded as both a 'friend and foe' of living organisms.

- (i) Explain this statement in terms of the role of ozone in the lower and upper atmosphere.

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The use of chlorofluorocarbons (CFCs), for example Freon (CF_2Cl_2), in the late 20th century has resulted in a reduction of stratospheric ozone.

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- (ii) Beginning with the production of a chlorine atom (radical) from Freon 12, describe using equations how ozone levels have decreased.

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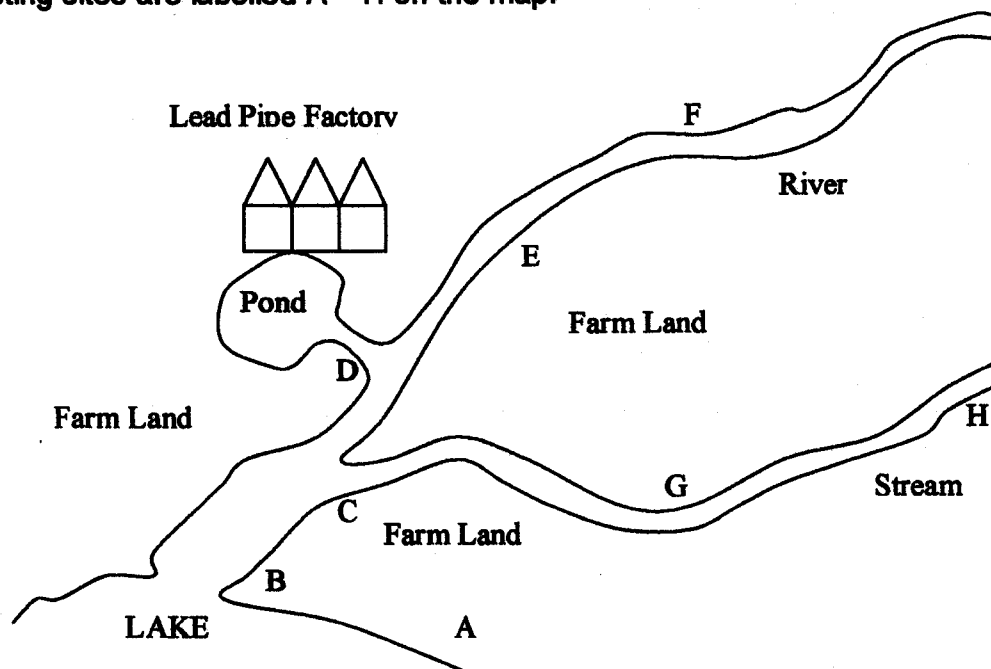
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Question 27 (7 marks)

The map below shows the location of various industries in relation to a river system. In order to evaluate the impact of industries on water quality, chemists working with the local water authority must determine the location of three testing sites. The possible testing sites are labelled A – H on the map.



Marks

- (i) What would be the most likely function of the pond associated with the Lead Pipe factory? Explain. 2

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- (ii) Identify the three sites most suitable for monitoring the impact of the industries on the river system. Justify each of your choices including information about the two most important water quality tests at each site(the two tests do not have to be the same at each site). 4

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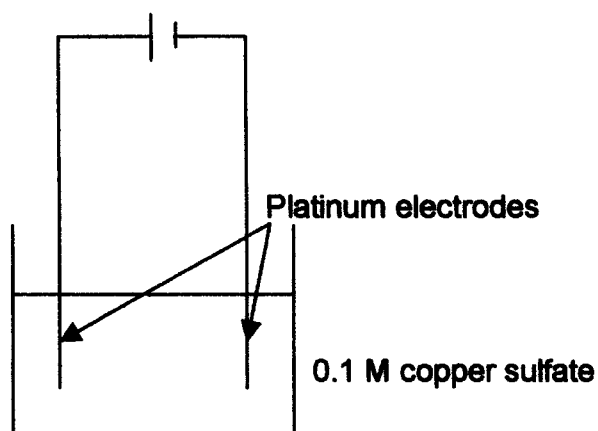
Section II

Question 28 - Shipwrecks and Salvage (25 marks) Allow about 45 minutes for this section.

Answer the question in an option answer booklet. Extra writing booklets are available. Show all relevant working in questions involving calculations.

	Mark
(a)	
(i) Draw a fully labelled diagram of the galvanic cell made from the two half cells; copper in a 1.0 mol L^{-1} solution of copper nitrate and beryllium in a 1.0 mol L^{-1} solution of beryllium nitrate. On your diagram indicate the direction of movement of all charged particles and the half equations at the specified electrodes. The beryllium is the negative electrode.	3
(ii) The measured EMF for this cell was 2.19V. Calculate the standard reduction potential for the beryllium half-cell.	1
(iii) Represent this galvanic cell in short hand notation.	1
(b)	
(i) Corrosion of ships is a major problem for ship owners and one that is both costly to combat and a constant concern. Describe a laboratory experiment that would demonstrate clearly the difference in rusting experienced by ocean going and freshwater river boats and the effect of increasing concentration of oxygen around the turbines driving the boats.	3
(ii) Predict the outcome of your experiment and justify your prediction.	3
(c)	
Discuss the chemistry of three different methods of protection of iron objects which are exposed to seawater. Each method should clearly demonstrate a totally different method of rust protection.	6

- (d) A student is supplied with the following electrolytic cell.



- (i) Write the half-cell reactions occurring at the anode and the cathode. **2**
- (ii) If copper electrodes were used instead of the platinum electrode, how would the overall cell reaction change ? **1**
- (iii) List three factors that could alter the rate of electrolysis in this experiment **2**
- (e) On its maiden voyage the Titanic struck an iceberg in deep water. It was predicted that the wreck would be in excellent condition. Explain why scientists believed this at that time, in terms of the expected conditions in deep water. **3**

