

**insight™**  
**Year 12 Trial Exam Paper**

**2014**

**CHEMISTRY**

**Written examination**

**STUDENT NAME:**

**QUESTION AND ANSWER BOOK**

**Reading time: 15 minutes**

**Writing time: 2 hours 30 minutes**

**Structure of book**

| <i>Section</i> | <i>Number of questions</i> | <i>Number of questions to be answered</i> | <i>Number of marks</i> |
|----------------|----------------------------|-------------------------------------------|------------------------|
| A              | 30                         | 30                                        | 30                     |
| B              | 11                         | 11                                        | 85                     |
|                |                            |                                           | Total 115              |

- Students are permitted to bring the following items into the examination: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
- Students are NOT permitted to bring sheets of paper or white out liquid/tape into the examination.

**Materials provided**

- The question and answer book of 27 pages
- An answer sheet for multiple-choice questions
- A Data Book

**Instructions**

- Remove the Data Book from this book during reading time.
- Write your **name** in the box provided.
- You must answer the questions in English.

**At the end of the examination**

- Place the multiple-choice answer sheet inside the front cover of this Question and Answer Book.

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**SECTION A – Multiple-choice questions****Instructions for Section A**

Answer **all** questions in pencil on the answer sheet provided for the multiple-choice questions. Choose the response that is **correct** or that **best answers** the question.

1 mark will be awarded for a correct answer; no marks will be awarded for an incorrect answer.

Marks are **not** deducted for incorrect answers.

No marks will be awarded if more than one answer is chosen for any question.

**Question 1**

Which one of the following contains the greatest number of oxygen atoms?

- A. 67.2 L of oxygen gas at STP
- B. 128 g of sulfur dioxide,  $\text{SO}_2$
- C. 5 moles of water
- D. 300 g of calcium carbonate,  $\text{CaCO}_3$

**Question 2**

The number of moles of oxygen gas required for the complete combustion of 64 g of methanol will be

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

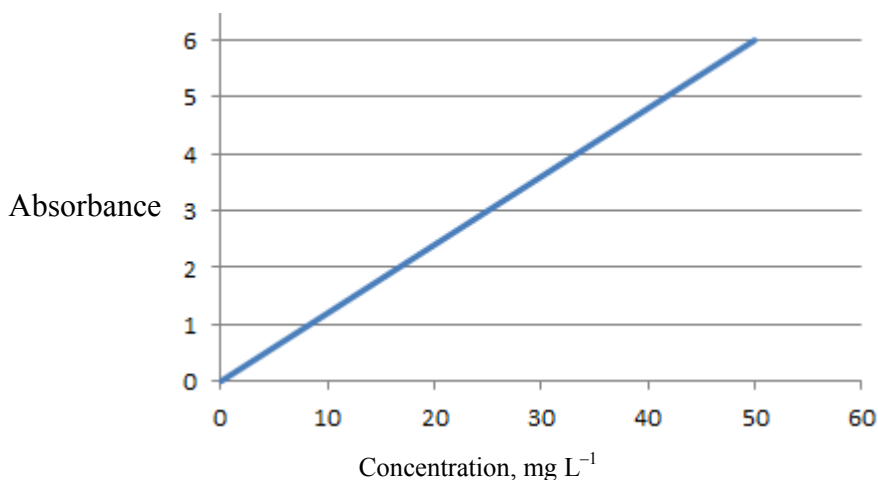
**Question 3**

After 92 g of sodium reacts completely with 34 g of oxygen gas, there should be

- A. none of either reactant left
- B. 2 g of oxygen unreacted
- C. 2 g of sodium unreacted
- D. 26 g of sodium unreacted

Use the following information to answer Questions 4 and 5.

The concentration of sodium ions in a solution can be determined by atomic absorption spectroscopy. The graph shown is a calibration curve for sodium solutions.



#### Question 4

When a sample of mineral water is tested, the absorbance is 3.0.

Assuming the sodium is present as sodium chloride, the sodium chloride concentration in the mineral water, in M, is closest to

- A.  $1.1 \times 10^{-3}$
- B.  $2.2 \times 10^{-3}$
- C. 0.11
- D. 0.43

#### Question 5

The same instrument settings are maintained for further analysis tasks.

Consider the following tasks.

- I Detection of the presence of sodium fluoride in a town water supply
- II Determination of the potassium chloride concentration in mineral water
- III Determination of the sodium nitrate concentration in sausage meat

Which analysis tasks could be performed successfully with the same instrument settings?

- A. III only
- B. I only
- C. I and III only
- D. I, II and III

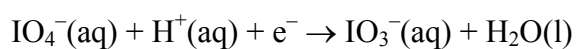
**Question 6**

A 20 mL aliquot of 0.25 M citric acid is titrated against a 0.40 M solution of sodium hydroxide. The average titre of sodium hydroxide is 37.5 mL. From this it can be concluded that citric acid

- A. must be a strong acid
- B. is a monoprotic acid
- C. is a diprotic acid
- D. is a triprotic acid

**Question 7**

In the half equation

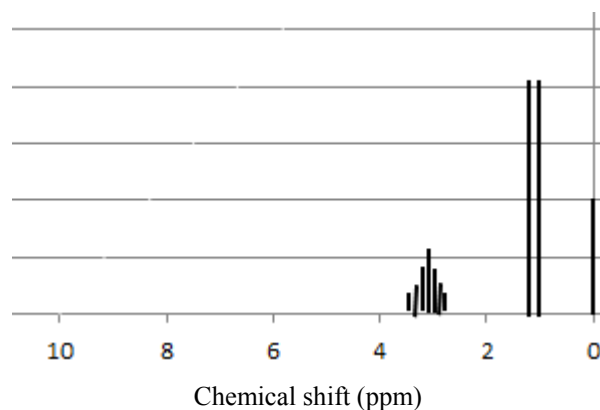


the oxidation number of iodine

- A. changes from -1 to 0
- B. changes from +7 to +5
- C. changes from +7 to +3
- D. is unchanged

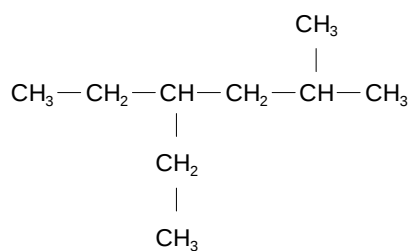
**Question 8**

A high-resolution proton NMR spectrum is shown below.



This NMR spectrum could be for

- A. 2-chloropropane
- B. 1-chloropropane
- C. propanoic acid
- D. propane

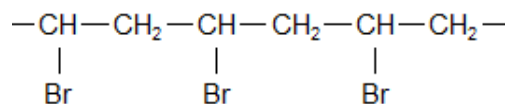
**Question 9**

The systematic IUPAC name for the molecule shown above is

- A. 4-ethyl-2-methylhexane
- B. 3-ethyl-5-methylhexane
- C. 2-methyl-5,5-diethylbutane
- D. nonane

**Question 10**

A segment of a polymer is shown below.



The monomer used to form this polymer is

- A. bromoethane
- B. bromoethene
- C. 1-bromoethene
- D. 1-bromopropane

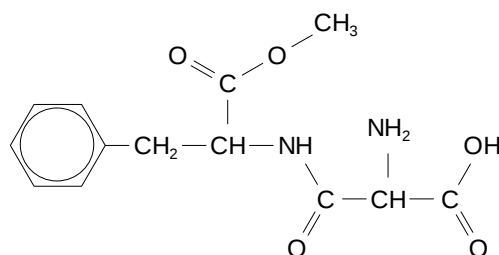
**Question 11**

The empirical formula of lysine is

- A.  $\text{CH}_2\text{O}_2\text{N}$
- B.  $\text{C}_3\text{H}_7\text{O}_2\text{N}_2$
- C.  $\text{C}_3\text{H}_7\text{ON}$
- D.  $\text{C}_6\text{H}_{14}\text{O}_2\text{N}_2$

**Question 12**

The molecule shown below is the artificial sweetener aspartame.



The functional groups present in aspartame are

- A. ester, amide, amine and carboxyl
- B. ester, amide, carboxyl and hydroxyl
- C. ester, amide and hydroxyl
- D. carboxyl, amide and hydroxyl

**Question 13**

Which of the following reactions involving glucose will be endothermic?

- A. glucose  $\rightarrow$  ethanol + carbon dioxide
- B. glucose + fructose  $\rightarrow$  sucrose + water
- C. glucose + oxygen  $\rightarrow$  carbon dioxide + water
- D. glucose + sulfuric acid  $\rightarrow$  carbon + water

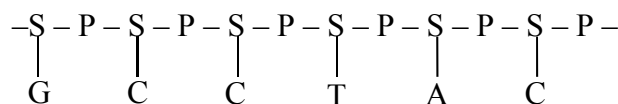
**Question 14**

When vinegar is added to warm milk, the milk curdles and separates in lumps of curd sitting in a whey solution. The effect of the vinegar on milk is to

- A. reduce the carbohydrates in milk to monosaccharides
- B. change the solubility of the fatty acids in milk
- C. hydrolyse the proteins in milk back to amino acids
- D. disrupt the tertiary structure of the proteins in milk

**Question 15**

A DNA strand is represented below.



The number of hydrogen bonds between this strand and its complementary strand will be

- A. 12
- B. 14
- C. 16
- D. 18

Use the following information to answer Questions 16 and 17.

The action of an enzyme is often referred to as a 'lock-and-key' mechanism, where the substrate attaches to the enzyme and a reaction occurs. A typical representation of this process is shown below.



### Question 16

An enzyme is able to function in this way because it has

- A. the potential to form very strong hydrogen bonds with a variety of molecules
- B. a specific shape that suits one particular substrate, weakening the bonds in the substrate
- C. a specific shape that will trap a variety of biomolecules, weakening the bonds in those molecules
- D. the potential to react with one particular substrate to form desired products

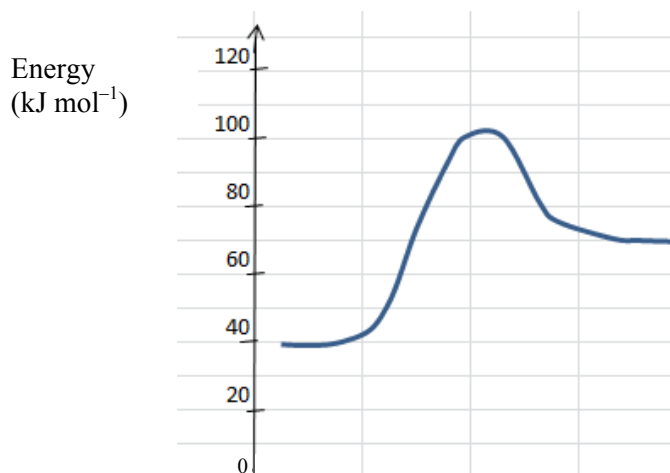
### Question 17

Sucrase is an enzyme that can hydrolyse sucrose back to its component monosaccharides. This reaction will

- A. produce two molecules of glucose
- B. form the polysaccharide glycogen in animals
- C. increase steadily in rate as the temperature approaches 100°C
- D. require water and produce two different monosaccharide molecules

**Question 18**

Consider the energy profile diagram for a reaction represented by the equation  $A + B \rightarrow C$ .



Which one of the following provides the correct values of the activation energy and enthalpy for the reaction  $C \rightarrow A + B$ ?

|    | Activation energy (kJ mol <sup>-1</sup> ) | Enthalpy (kJ mol <sup>-1</sup> ) |
|----|-------------------------------------------|----------------------------------|
| A. | +62                                       | +30                              |
| B. | +32                                       | +30                              |
| C. | -32                                       | -30                              |
| D. | +32                                       | -30                              |

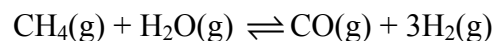
**Question 19**

Which one of the following solutions has the highest hydroxide ion (OH<sup>-</sup>) concentration?

- A. 0.001 M HCl
- B. 0.1 M H<sub>3</sub>BO<sub>3</sub>
- C. 0.01 M H<sub>3</sub>BO<sub>3</sub>
- D. 0.01 M HCOOH

*Use the following information to answer Questions 20 and 21.*

Hydrogen gas can be formed from the endothermic, reversible reaction between methane and steam:



**Question 20**

A change is made to an equilibrium mixture of the aforementioned gases that results in the total number of particles present increasing by 0.04 mole. The change could have been

- A. a decrease in temperature
- B. the addition of a catalyst
- C. an increase in pressure
- D. an increase in volume

**Question 21**

When the volume of a reaction mixture is doubled, the concentration of each component

- A. is immediately halved
- B. drops by the same amount
- C. will immediately double
- D. will adjust slowly until all values are halved

**Question 22**

The pH of a sample of pure water is recorded as being 6.6.

- A. This is not possible as water has a pH of 7.
- B. The hydroxide ion concentration in this sample is  $10^{-6.6}$ .
- C. The hydroxide ion concentration in this sample is  $10^{-7.4}$ .
- D. The value of  $[\text{H}_3\text{O}^+]$  cannot be equal to  $[\text{OH}^-]$  in this sample.

**Question 23**

The student Data Book contains a table on page 11 that lists the molar enthalpy values for some common fuels. This table can be used to show that

- A. carbon releases more energy per gram than hydrogen gas
- B. structural isomers release the same amount of energy as each other
- C. ethanol releases more energy per gram than ethane
- D. pentane releases more energy per mole than butane

**Question 24**

Ethanol can be used to calibrate a bomb calorimeter. When 0.500 g of ethanol undergoes complete combustion in a calorimeter, the temperature increases from 18.6°C to 33.4°C. The calibration factor for the calorimeter, in  $\text{kJ C}^{-1}$ , is

- A. 1.00
- B. 2.00
- C. 14.8
- D. 1000

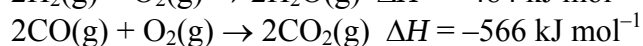
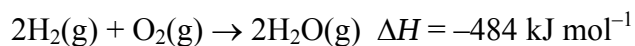
**Question 25**

Select the correct statement about energy sources.

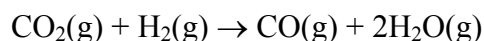
- A. Uranium undergoes nuclear fusion in a nuclear reactor.
- B. Coal is an energy-dense source of electricity.
- C. The efficiency of a photovoltaic cell is relatively low.
- D. Natural gas is a sustainable form of energy.

**Question 26**

The  $\Delta H$  values for two reactions are:

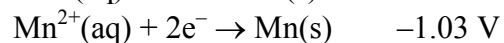
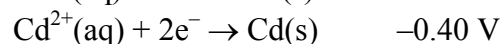


Use the information supplied to determine  $\Delta H$  in  $\text{kJ mol}^{-1}$  for the reaction:



- A. -1050
- B. -41
- C. +41
- D. +1050

Use the following information to answer Questions 27 and 28.



### Question 27

The strongest reductant on the table provided is

- A. Ba(s)
- B.  $\text{Ba}^{2+}(\text{aq})$
- C. Ni(s)
- D.  $\text{Cd}^{2+}(\text{aq})$

### Question 28

A spontaneous reaction could occur between

- A. cadmium and manganese nitrate
- B. manganese and cadmium nitrate
- C. nickel and barium nitrate
- D. nickel and manganese nitrate

### Question 29

Which one of the following statements is true for both galvanic cells and electrolytic cells?

- A. The anode is positive in both cells.
- B. Electrons flow from the positive to the negative electrode in both cells.
- C. Reduction occurs in the cathode in both cells.
- D. A salt bridge is required for both cells.

### Question 30

Tin is a metal that has more than one oxidation state. An aqueous solution of tin nitrate is electrolysed and tin is deposited onto the cathode. When a current of 2.50 amps runs for 35 minutes, the mass of tin deposited is 1.62 g. The formula of the tin nitrate used in this cell is

- A.  $\text{SnNO}_3$
- B.  $\text{Sn}(\text{NO}_3)_2$
- C.  $\text{Sn}_2(\text{NO}_3)_3$
- D.  $\text{Sn}(\text{NO}_3)_4$

**END OF SECTION A**  
**TURN OVER**

**SECTION B – Short-answer questions****Instructions for Section B**

Answer **all** questions in the spaces provided. Write using black or blue pen.

To obtain **full marks** for your responses you should

- Give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full marks.
- Show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- Make sure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example,  $\text{H}_2(\text{g})$ ;  $\text{NaCl}(\text{s})$ .

**Question 1 (8 marks)**

A semi-structural diagram of a common biomolecule is drawn below.



- a. i.** What group of biomolecules does this molecule belong to?

1 mark

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- ii.** Name this molecule.

1 mark

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- iii.** Will this molecule be a solid or liquid at room temperature?  
Explain your answer.

1 mark

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- b. i.** Use this molecule to explain what ‘polyunsaturated’ means.

1 mark

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- ii.** The solubility of this molecule in water is low. Explain why this is the case.

1 mark

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- c.** Write a balanced equation for the complete combustion of this molecule.

2 marks

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- d.** A molecule of biodiesel can be formed when methanol is reacted with the above molecule in strong alkaline solution.  
Draw a semi-structural formula of the biodiesel molecule formed.

1 mark

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**SECTION B – continued**  
**TURN OVER**

**Question 2** (8 marks)

One of the by-products of the combustion of petrol in car engines is nitrogen oxide, NO. This is a colourless gas that reacts further in air to form nitrogen dioxide, NO<sub>2</sub>. The equation for this reversible reaction is:



Nitrogen dioxide is the distinctive brown gas evident in smog over large cities.

- a. Write 'increase', 'decrease' or 'no change' in the table below to identify the expected effect of each change on the equilibrium constant and on the colour of the equilibrium mixture.

3 marks

| Change                                 | Effect of the change on the value of $K$ | Effect of the change on the colour intensity of the equilibrium mixture |
|----------------------------------------|------------------------------------------|-------------------------------------------------------------------------|
| Addition of oxygen gas                 |                                          |                                                                         |
| Increase in the volume of the reactor  |                                          |                                                                         |
| Increase in temperature of the reactor |                                          |                                                                         |

- b. Car exhaust pipes contain catalytic converters. Explain the impact of the catalytic converter on the reaction for the production of nitrogen dioxide.

1 mark

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- c. 0.80 mole of NO<sub>2</sub> is added to 1.0 L of reactor. At equilibrium, 0.64 mole of NO<sub>2</sub> is present. Calculate the numerical value of the equilibrium constant at this temperature.

4 marks

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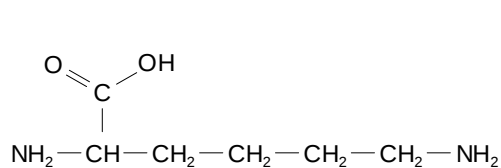
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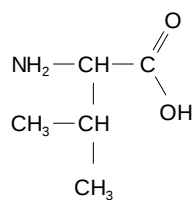
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**Question 3** (7 marks)

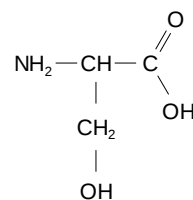
The structures of three amino acids are drawn below.



Amino acid A



Amino acid B



Amino acid C

- a. i.** What chemical features must an amino acid have to be classified as an  $\alpha$ -amino acid?

1 mark

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- ii.** Which amino acid is the least soluble in water? Explain your answer.

1 mark

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- iii.** Which amino acid will form an alkaline solution in pure water? Explain your answer.

1 mark

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- b. i.** How many different tripeptides could be formed from the three amino acids above? 1 mark

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- ii.** How many peptide linkages are formed when a tripeptide forms? 1 mark

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- c.** Draw the structure, showing all bonds, of amino acid C as it would exist in a solution of pH 11. 1 mark

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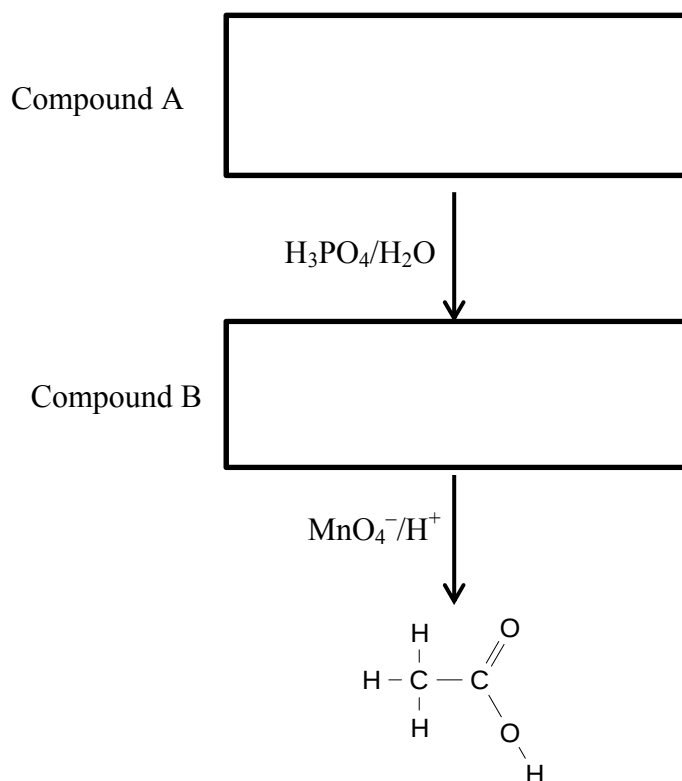
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- d.** Why does a particular enzyme generally catalyse only one specific reaction? 1 mark

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**Question 4** (12 marks)

A reaction pathway for the synthesis of ethanoic acid is shown below.



- a.** In the appropriate boxes above, draw the structures of compound A and compound B.

2 marks

- b.** Give the systematic IUPAC name for compounds A and B.

2 marks

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- c.** The reaction of compound B to ethanoic acid is a redox reaction. Use the spaces below to write balanced half equations and an overall equation for this reaction.

3 marks

Anode reaction:

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Cathode reaction:

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Overall reaction:

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- d.** To make the synthesis of ethanoic acid more sustainable, compound B could be produced from over-ripe fruit. Write a balanced equation for the formation of compound B by this process.

1 mark

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- e.** The synthesis of ethanoic acid is conducted in an aqueous environment, so the product is a solution of ethanoic acid. To determine the concentration of this solution, a 10.0 mL sample is diluted to 100 mL and then 20.0 mL aliquots are titrated against a 0.204 M sodium hydroxide (NaOH) solution. The average titre obtained is 32.6 mL.

- i.** Write a balanced equation for the reaction occurring in the titration.

1 mark

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- ii.** Use the titre obtained to determine the concentration of the original ethanoic acid solution.

3 marks

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**Question 5 (6 marks)**

- a.** Proton NMR spectra are produced to distinguish a sample of methylpropane from butane. Explain one difference between the two spectra. 1 mark

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- b.** Infrared spectra are produced to distinguish a sample of ethanoic acid from ethanol. Identify one piece of information from each spectrum that can be used to identify the compound. 1 mark

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- c.** A 0.8 M solution of ethanol is passed through a gas chromatograph. Next, a 0.02 M solution of ethanol is passed through the same column. Identify one similarity between the two chromatograms and one difference between them. 2 marks

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- d.** The concentration of iron(III) thiocyanate solutions can be determined accurately by using a UV spectrophotometer set to a wavelength of 480 nm. This method does not work for determining the concentration of iron(III) nitrate solutions. Suggest a reason why. 1 mark

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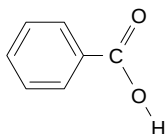
- e.** The abundance of the parent molecular ion in the mass spectrum of butanoic acid is very low. Suggest a reason for this. 1 mark

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**Question 6** (7 marks)

The molecule drawn below is benzoic acid.



- a.** Write a balanced equation for the reaction of benzoic acid in water.

1 mark

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- b.** Use your equation from part **a.** to explain why the solubility of benzoic acid is increased by the addition of a small volume of sodium hydroxide (NaOH) solution.

1 mark

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- c. i.** Calculate the pH of a 0.1 M solution of benzoic acid at 25°C.

3 marks

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- ii.** What is the percentage ionisation of the benzoic acid in this solution?

2 marks

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**Question 7** (6 marks)

A 4.000 g sample of a hydrocarbon is extracted from the leaves of a plant. Upon combustion of this sample, the mass of water obtained is 6.540 g and the mass of carbon dioxide is 11.980 g.

- a.** Calculate the empirical formula of the compound.

3 marks

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- b. i.** The molar mass of the molecule is  $44 \text{ g mol}^{-1}$ . What is the molecular formula of the molecule?

1 mark

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- ii.** Draw and name the molecule.

2 marks

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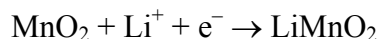
**SECTION B – continued**  
**TURN OVER**

**Question 8** (11 marks)

Lithium is an excellent metal to use in a battery because it is very reactive and very light in weight. The potential energy density that a lithium cell offers is greater than that of most conventional batteries. Lithium cells need to operate in a water-free environment because the reaction with water is very vigorous. In recent years there has been a spate of incidents of toddlers swallowing these small shiny cells, with tragic consequences.

The simplest primary cell using lithium is the lithium–manganese cell.

The half equation occurring at the manganese dioxide electrode in this cell is:



- a. i.** At which electrode will this half equation take place? \_\_\_\_\_ 1 mark

- ii.** Use the spaces provided to identify the element that is changing oxidation state in this half reaction and write down the change that is occurring. 3 marks

Element: \_\_\_\_\_

Oxidation number before reaction: \_\_\_\_\_

Oxidation number after reaction: \_\_\_\_\_

- b.** Knowing that this is a lithium–manganese cell, give the other half equation occurring and the overall equation for the cell. 2 marks

Half equation \_\_\_\_\_

Overall equation \_\_\_\_\_

- c. i.** Write a balanced equation for the reaction of lithium in water. 1 mark

\_\_\_\_\_

- ii.** Give one reason why this reaction represents a safety issue for this cell. 1 mark

\_\_\_\_\_

- d.** Calculate the mass of lithium consumed in this cell when it operates at a current of 0.48 amps for 2.0 hours. 3 marks

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**Question 9 (6 marks)**

One of the many fuel cells subjected to research programs is the DMFC cell, where DMFC stands for direct methanol fuel cell. This utilises a 3% methanol solution, with oxygen gas being the other reactant. The electrolyte used is acidic. The cell does not produce a high power output but it is capable of producing power over a long period of time. It has military uses as it can operate at low temperatures and is therefore not visible on thermal imaging detectors.

- a. i.** The reaction of methanol in this cell is the same reaction as that for the combustion of methanol. Write a balanced overall equation for the combustion of methanol.

1 mark

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- ii.** Write a balanced half equation for the reaction occurring at the:

2 marks

Anode 

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Cathode 

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- b. i.** One practical problem associated with this cell is that airlines have placed a limit of 200 mL on the volume of flammable liquids that can be carried on commercial airlines. What is the mass of 200 mL of pure methanol?

Note: The density of methanol is  $0.792 \text{ g mL}^{-1}$ .

1 mark

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- ii.** Calculate the maximum amount of energy that could be released from this quantity of methanol.

2 marks

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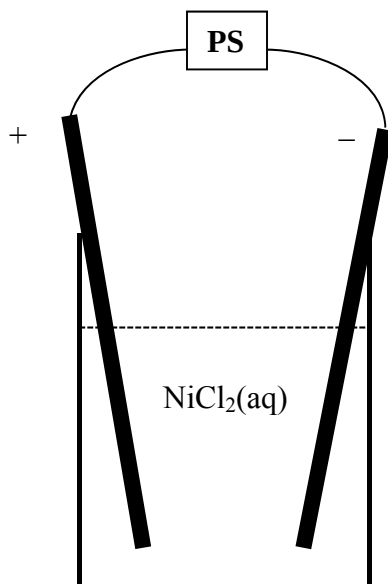
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**SECTION B – continued**  
**TURN OVER**

**Question 10** (8 marks)

A power supply is connected to electrodes in a dilute aqueous solution of nickel(II) chloride. A current of 3.00 amps is passed through the solution for 35.0 minutes.



- a.** Calculate the mass of metal deposited at the cathode.

3 marks

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- b.** Calculate the volume of gas produced at the anode if the gas is stored at STP.

3 marks

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- c. Give one reason why this cell cannot run indefinitely.

1 mark

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- d. How will the pH of the solution change during the operation of the cell?

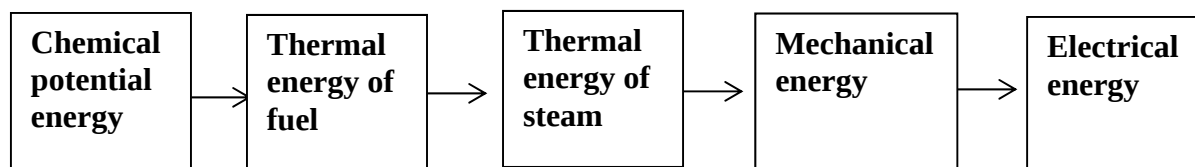
1 mark

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**SECTION B – continued**  
**TURN OVER**

**Question 11** (6 marks)

A flowchart for the production of electrical energy is shown below.



- a. i.** Which form of electricity production does this flowchart illustrate?

1 mark

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- ii.** State one advantage of this process.

1 mark

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- iii.** State two disadvantages of this process.

2 marks

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- b.** Is energy conserved in the production of mechanical energy from thermal energy? Explain your answer.

1 mark

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- c.** Explain briefly how mechanical energy is converted to electrical energy.

1 mark

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**END OF QUESTION AND ANSWER BOOK**

**END OF SECTION B**