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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

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
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.

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, SO_2

C. 5 moles of water

D. 300 g of calcium carbonate, $CaCO_3$

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

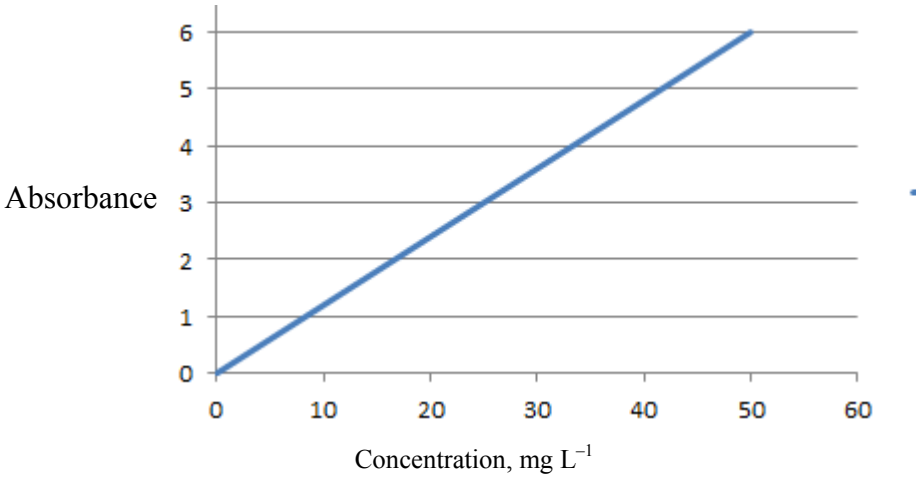
B. 2 g of oxygen unreacted

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. 1.1×10^{-3}

B. 2.2×10^{-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

$IO_4^-(aq) + H^+(aq) + e^- \rightarrow IO_3^-(aq) + H_2O(l)$

the oxidation number of iodine

A. changes from –1 to 0

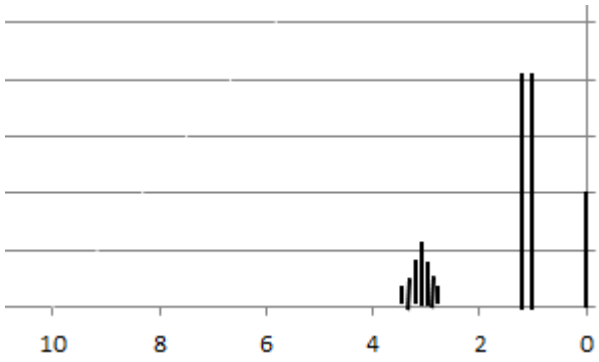
B. changes from +7 to +5

C. changes from +7 to +3

D. is unchanged

Question 8

A high-resolution proton NMR spectrum is shown below.



Chemical shift (ppm)

This NMR spectrum could be for

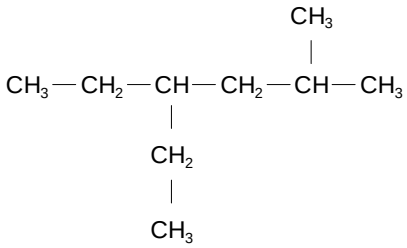
A. 2-chloropropane

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

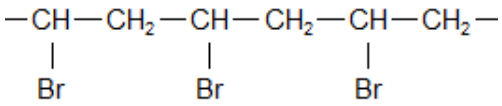
B. 3-ethyl-5-methylhexane

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. CH_2O_2N

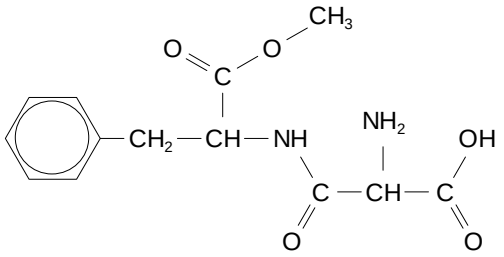
B. $C_3H_7O_2N_2$

C. C_3H_7ON

D. $C_6H_{14}O_2N_2$

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

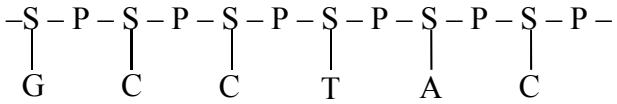
Question 14

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.

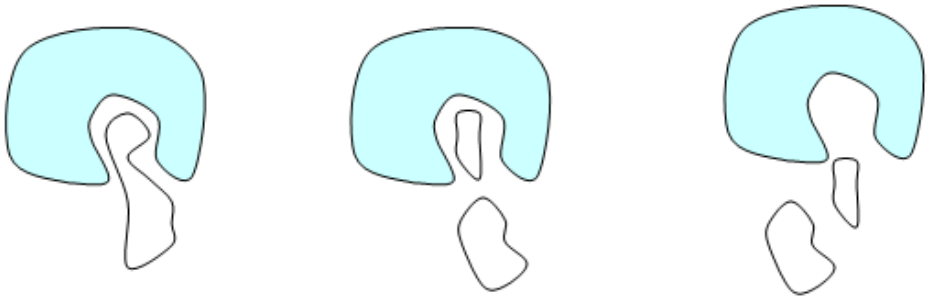


The number of hydrogen bonds between this strand and its complementary strand will be

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

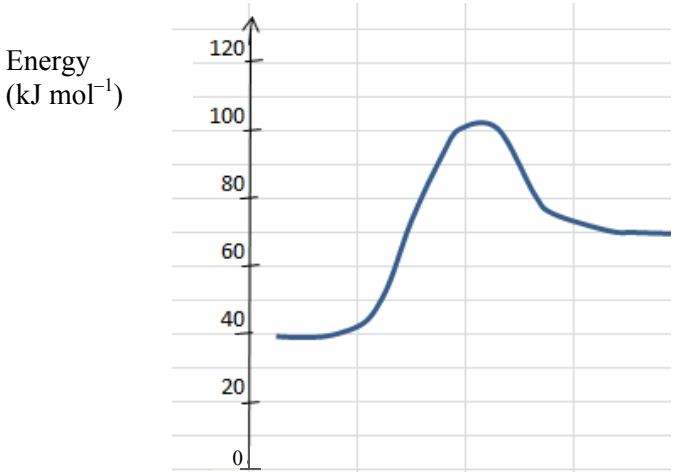
B. form the polysaccharide glycogen in animals

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 → C.



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

	Activation energy (kJ mol^{-1})	**Enthalpy** (kJ mol^{-1})
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^-) concentration?

A. 0.001 M HCl

B. 0.1 M H_3BO_3

C. 0.01 M H_3BO_3

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:

$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$

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 $[H_3O^+]$ cannot be equal to $[OH^-]$ 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 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 ΔH values for two reactions are:

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g) \quad \Delta H = -484$ kJ mol^{-1}
$2CO(g) + O_2(g) \rightarrow 2CO_2(g) \quad \Delta H = -566$ kJ mol^{-1}

Use the information supplied to determine ΔH in kJ mol^{-1} for the reaction:

$CO_2(g) + H_2(g) \rightarrow CO(g) + 2H_2O(g)$

A. –1050
B. –41
C. +41
D. +1050

Use the following information to answer Questions 27 and 28.

$Ba^{2+}(aq) + 2e^- \rightarrow Ba(s)$ –2.90 V
$Cd^{2+}(aq) + 2e^- \rightarrow Cd(s)$ –0.40 V
$Mn^{2+}(aq) + 2e^- \rightarrow Mn(s)$ –1.03 V
$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$ –0.23 V

Question 27

The strongest reductant on the table provided is

A. Ba(s)

B. $Ba^{2+}(aq)$

C. Ni(s)

D. $Cd^{2+}(aq)$

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. $SnNO_3$

B. $Sn(NO_3)_2$

C. $Sn_2(NO_3)_3$

D. $Sn(NO_3)_4$

END OF SECTION A
TURN OVER

SECTION B – Short-answer questions

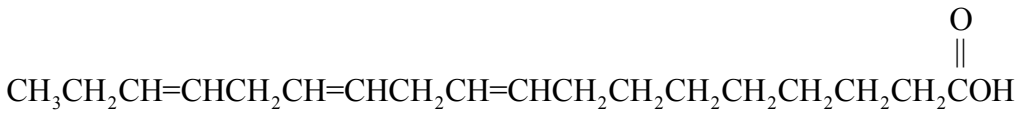
Instructions for Section B

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, $H_2(g)$; NaCl(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

_____

ii. Name this molecule.

1 mark

_____

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

1 mark

_____

_____

_____

SECTION B – QUESTION 1 – continued

b. **i.** Use this molecule to explain what 'polyunsaturated' means.

1 mark

_____

_____

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

1 mark

_____

_____

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

2 marks

_____

_____

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

_____

_____

_____

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_2. The equation for this reversible reaction is:

$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g) \quad \Delta H = -56 \text{ kJ mol}^{-1}$

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

_____

c. 0.80 mole of NO_2 is added to 1.0 L of reactor. At equilibrium, 0.64 mole of NO_2 is present. Calculate the numerical value of the equilibrium constant at this temperature.

4 marks

_____

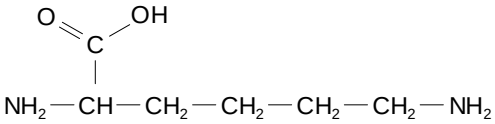
_____

_____

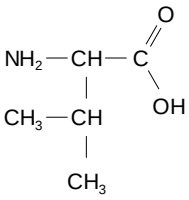
_____

Question 3 (7 marks)

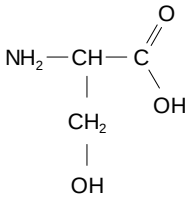
The structures of three amino acids are drawn below.



Amino acid A



Amino acid B



Amino acid C

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

1 mark

_____

_____

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

1 mark

_____

_____

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

1 mark

_____

_____

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

1 mark

_____

ii. How many peptide linkages are formed when a tripeptide forms?

1 mark

_____

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

1 mark

_____

_____

_____

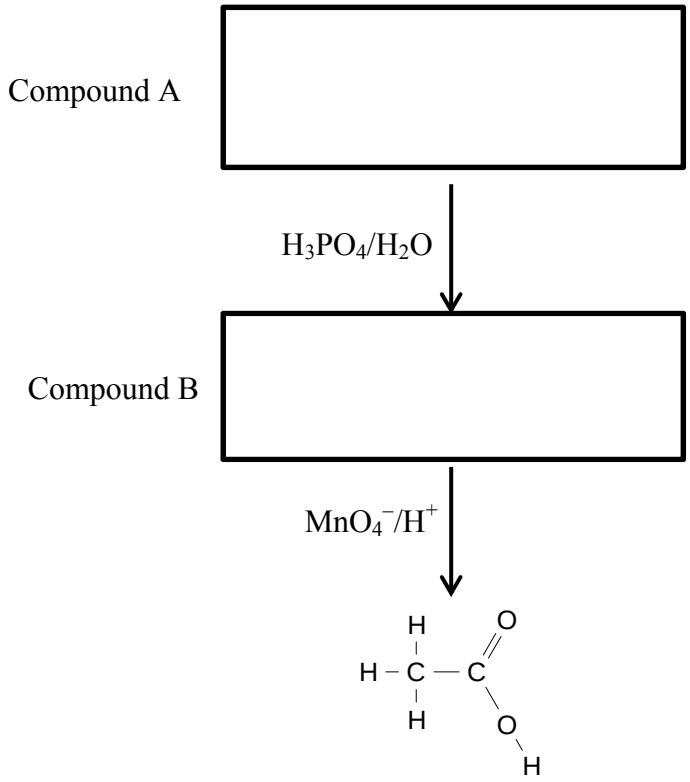
d. Why does a particular enzyme generally catalyse only one specific reaction?

1 mark

_____

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

_____

_____

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:

_____

Cathode reaction:

_____

Overall reaction:

_____

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

_____

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

_____

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

3 marks

_____

_____

_____

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

_____

_____

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

_____

_____

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

_____

_____

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

_____

_____

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

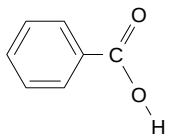
1 mark

_____

_____

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

_____

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

_____

_____

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

3 marks

_____

_____

_____

_____

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

2 marks

_____

_____

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

_____

_____

_____

_____

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

1 mark

_____

ii. Draw and name the molecule.

2 marks

_____

_____

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:

$MnO_2 + Li^+ + e^- \rightarrow LiMnO_2$

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

_____

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

2 marks

Anode_____

Cathode_____

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 g mL^{-1}.

1 mark

_____

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

2 marks

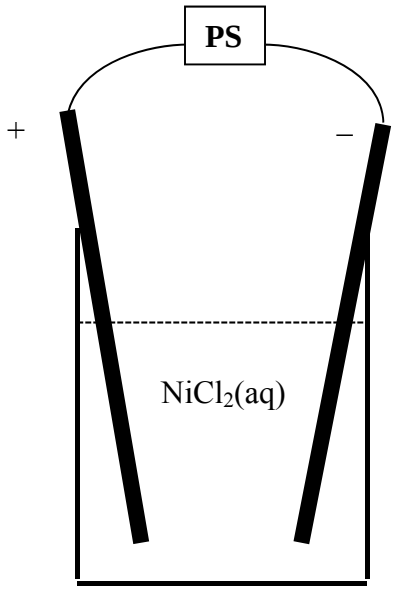
_____

_____

_____

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

_____

_____

_____

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

3 marks

_____

_____

_____

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

1 mark

_____

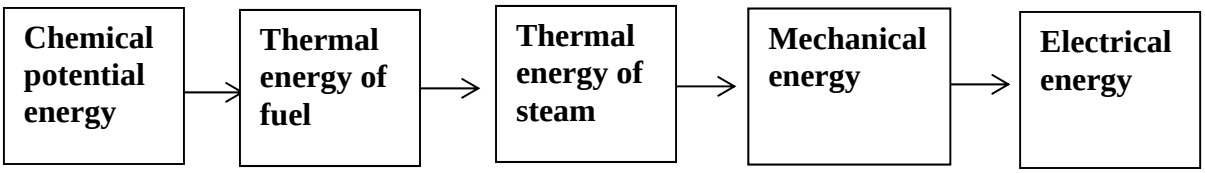
d. How will the pH of the solution change during the operation of the cell?

1 mark

_____

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

_____

ii. State one advantage of this process.

1 mark

_____

iii. State two disadvantages of this process.

2 marks

_____

_____

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

1 mark

_____

_____

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

1 mark

_____

_____

END OF QUESTION AND ANSWER BOOK

END OF SECTION B