ACCESS EDUCATION

Name _____

Student Number _____

ACCESS.EDUCATION 2017

CHEMISTRY
Unit 3 & 4
Trial Examination

Reading time: 15 minutes
Total writing time: 2 hours and 30 minutes

Structure of Booklet

Section	Number of questions	Marks
A	30	30
B	10	80
Total		**110**

Directions to students

- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.
- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.

Materials supplied

- Write your Name/Student number in the space provided above on this page

Question and answer book

- Answer sheet for multiple-choice questions.

Instructions

- Write your student number in the space provided above on this page.
- All written responses must be in English.

At the end of the examination

- Place the answer sheet for multiple-choice questions inside the front cover of this book.

SECTION A – Multiple-choice questions

Instructions for Section A

Answer all questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is correct or that best answers the question.
A correct answer scores 1, an incorrect answer scores 0.
Marks will not be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.

Question 1
Different quantities of nitrogen oxide (NO) are listed below. Which one contains the least number of molecules?

A. 6×10^2 L at 273 K and 1 atm
B. 6×10^{23} molecules
C. 6×10^2 g
D. 6 mol

Question 2
In which one of the following compounds does the transition metal display the lowest oxidation state?

A. CrO_3
B. Cu_2S
C. $MnCl_2$
D. $K_2Cr_2O_7$

Question 3
A chemical reaction has a ΔH of 150 kJ mol^{-1} and the activation energy for its reverse reaction is 350 kJ mol^{-1}.
The activation energy of the forward reaction is

A. + 500 kJ mol^{-1}
B. + 200 kJ mol^{-1}
C. + 150 kJ mol^{-1}
D. – 200 kJ mol^{-1}

Question 4
Which of the following statements about enzymes are correct?

I Enzymes are proteins.
II Enzymes increase the rate of biochemical reactions.
III Enzymes increase the equilibrium constant of biochemical reactions.

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

Question 5
In coal fired power stations, the amount of electrical energy produced is less than half of the chemical energy of the coal consumed. This is mainly due to:

A. the incomplete combustion of the coal and partial releases of its chemical energy for the generation process
B. the less than 100 % efficiencies of the energy transformation that occur at the power station
C. the number of energy transformations required to convert the chemical energy from the coal into electrical energy
D. the large amounts of energy required to convert water into steam that is used in the generation process

Question 6
The electrolyte used to produce the major proportion of the chlorine gas commercially produced using electrolytic cells is
A. a molten mixture containing calcium chloride and sodium chloride.
B. concentrated aqueous hydrochloric acid.
C. concentrated aqueous sodium chloride.
D. dilute aqueous sodium chloride.

Question 7
The oxidation of sulfur dioxide, SO_2, can be represented by the following chemical equation

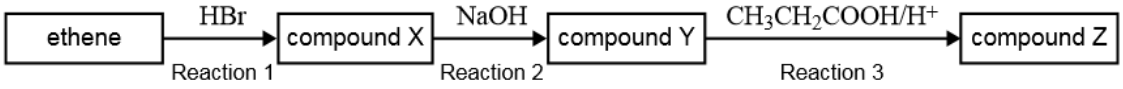
$$2SO_{2\,(g)} + O_{2\,(g)} \rightleftharpoons 2SO_{3\,(g)} \;:\; \Delta H = -198 \text{ kJ mol}^{-1}$$

Adding more than the stoichiometric amount of oxygen to a sample of sulfur dioxide will:

A. increase the equilibrium yield of sulfur trioxide.
B. decrease the value of the equilibrium constant.
C. increase the value of the equilibrium constant.
D. decrease the equilibrium yield of sulfur trioxide

Questions 8 and 9 refer to the following information.

Ethene can be converted into other carbon-containing compounds using the reagents shown in this flow chart.



Question 8
Compounds X, Y and Z are, respectively

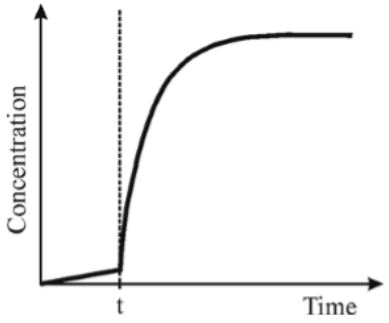
A. bromoethane, ethanol, propyl ethanoate
B. bromoethane, ethanol, ethyl propanoate
C. bromoethene, ethanoic acid, ethyl propanoate
D. bromoethene, ethene hydroxide, propyl ethanoate

Question 9
Reactions 1, 2 and 3 can be described as, respectively

A. addition, addition, neutralisation
B. addition, substitution, condensation
C. substitution, neutralisation, oxidation
D. substitution, substitution, condensation

Question 10

The graph below shows how the concentration of a product in a gas phase equilibrium reaction varied with time. A change to the system occurred at time t.

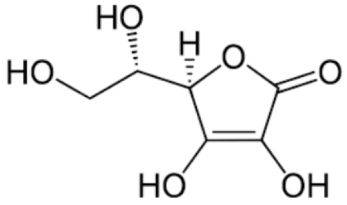


The best explanation for the change that occurred at time t is that

A. some of the product was removed from the mixture.
B. a catalyst was added to the mixture.
C. the temperature of the mixture was decreased.
D. more reactant was added to the mixture.

Question 11

The structure of vitamin C is shown here:



Vitamin C is an important biological molecule and is often added to foods as an antioxidant. Based on this information, and on the structure of vitamin C shown above, it can be predicted that vitamin C is more soluble in

A. fats than in water and is a good oxidant.
B. fats than in water and is a good reductant.
C. water than in fats and is a good oxidant.
D. water than in fats and is a good reductant.

Question 12

A fuel cell currently under development for powering small electronic devices utilises the reaction of methanol, oxygen and an acidic electrolyte. The reductant in the cell reaction and the half reaction at the anode are:

	reductant	**anode reaction**
A.	methanol	$O_{2\,(g)} + 4H^+_{(aq)} + 4e \longrightarrow 2H_2O_{\,(l)}$
B.	oxygen	$O_{2\,(g)} + 4H^+_{(aq)} + 4e \longrightarrow 2H_2O_{\,(l)}$
C.	methanol	$CH_3OH_{\,(g)} + H_2O_{\,(l)} \longrightarrow CO_{2\,(g)} + 6H^+_{(aq)} + 6e^-$
D.	oxygen	$CH_3OH_{\,(g)} + H_2O_{\,(l)} \longrightarrow CO_{2\,(g)} + 6H^+_{(aq)} + 6e^-$

Question 13

The ester, propyl butanoate, is used as a food flavouring. The correct semi-structural formula for propyl butanoate is

A. $CH_3CH_2CH_2COOCH_2CH_2CH_3$
B. $CH_3COOCH_2CH_2CH_2CH_2CH_3$
C. $CH_3CH_2CH_2CH_2CH_2COOCH_2CH_3$
D. $CH_3CH_2CH_2CH_2COOCH_2CH_2CH_3$

Question 14

Increasing the pressure of a gas phase reaction will result in an increase in the rate of reaction because

A. the particles will have a higher kinetic energy.

B. more particles will have energies greater than the activation energy, therefore there will be more fruitful collisions between the reactant particles.

C. the particles occupy a smaller volume.

D. there will be a higher chance of fruitful collisions between the reactant particles.

Question 15

The main advantage of using biodiesel to replace diesel fuel obtained from crude oil is that

A. biodiesel does not produce any greenhouse gases when it is burnt in engines

B. biodiesel is cheaper to produce than diesel fuels derived from crude oil

C. diesel derived from crude oil requires an expensive distillation process not required in biodiesel production

D. fossil fuels are being consumed in diesel production, whereas biodiesel is produced from renewable materials

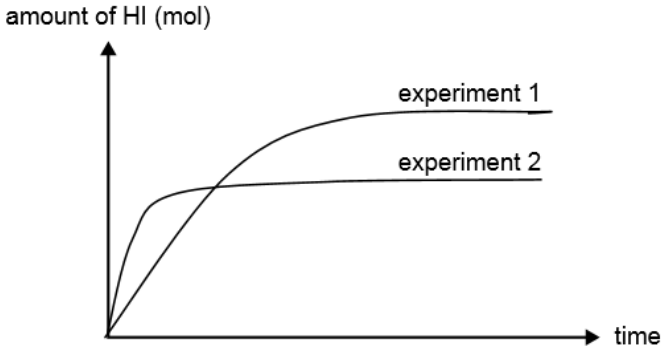
Question 16

Hydrogen iodide is produced by the reaction between hydrogen and iodine: $H_{2\,(g)} + I_{2\,(g)} \rightleftharpoons 2HI_{\,(g)}$

Two experiments investigating this reaction were conducted.

Experiment 1: quantities of $H_{2\,(g)}$ and $I_{2\,(g)}$ were placed in a sealed vessel and the reaction allowed to proceed at constant temperature.

Experiment 2: experiment 1 was repeated, but at a different temperature. The graph below shows the amount of hydrogen iodide produced over the course of experiments 1 and 2.



These results show that experiment 2 was conducted at a

A. lower temperature than experiment 1 and the reaction is endothermic

B. lower temperature than experiment 1 and the reaction is exothermic

C. higher temperature than experiment 1 and the reaction is endothermic

D. higher temperature than experiment 1 and the reaction is exothermic

Question 17

Methane obtained from natural gas wells is considered as a non-renewable resource, yet methane generated by the anaerobic digestion of organic materials is classed as a renewable fuel because

A. it is a different material and has different properties

B. it is obtained from plant materials only

C. it does not contribute to greenhouse gas emissions

D. it can be replaced in a short time frame from renewable resources

Question 18

Hydrogen gas can be produced from a variety of methane sources. The equation for the reaction is:

$$CH_{4\,(g)} + 2H_2O_{\,(g)} + \rightleftharpoons 4H_{2\,(g)} + CO_{2\,(g)}$$

If the reaction is reversed, the expression for the equilibrium constant is:

A. $K = \dfrac{[H_2O]^2\,[CH_4]}{[H_2]^4\,[CO_2]}$

B. $K = \dfrac{[H_2]^4\,[CO_2]}{[H_2O]^2\,[CH_4]}$

C. $K = \dfrac{[H_2O]\,[CH_4]}{[H_2]\,[CO_2]}$

D. $K = \dfrac{4[H_2]\,[CO_2]}{2[H_2O]\,[CH_4]}$

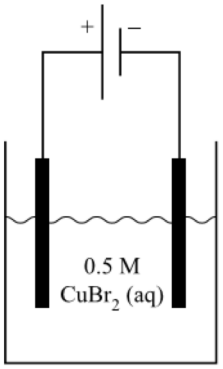
Question 19

Lithium-ion cells are excellent power sources for high-drain devices such as portable computers and mobile phones. These consist of an anode of lithium metal absorbed into graphite, a solid metal oxide cathode such as CoO_2, and a polymer electrolyte containing a dissolved metal salt. Which of the following reactions could not occur as the cell is discharging?

A. $Li \longrightarrow Li^+ + e^-$
B. $CoO_2 + Li^+ + e^- \longrightarrow LiCoO_2$
C. $Li + CoO_2 \longrightarrow LiCoO_2$
D. $LiCoO_2 \longrightarrow Li + CoO_2$

Question 20

If the electrolytic cell shown here is operating at 25^0C and 1 atm pressure, an observer of the cell would see:



A. no reaction at all because the process is endothermic
B. a colourless gas at the cathode and a metallic coating on the anode
C. a coloured liquid at the anode and a metallic coating on the cathode
D. a colourless gas at the anode and a coloured liquid at the cathode

Question 21

With reference to the Electrochemical Series, which of the following compounds would have the same product at the anodes but a different product at the cathodes when comparing the electrolysis of its molten state with the electrolysis of the compound in a 1.0 M aqueous solution?

A. Sodium fluoride
B. Zinc chloride
C. Lead iodide
D. Potassium bromide

Question 22

A sample of argon gas occupies 48 L at 15°C and 720 mmHg. If the sample is heated to 30°C and the volume drops to 24 L, the new pressure will be closest to

A. 200 kPa
B. 300 kPa
C. 2000 kPa
D. 3000 kPa

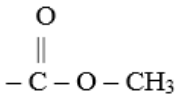
Question 23

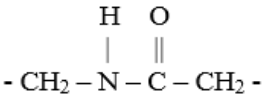
Which of the following compounds contains the highest percentage by mass of oxygen?

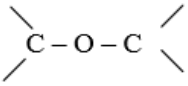
A. Butyl propanoate
B. 1-butanol
C. Butanoic acid
D. 1-aminobutane

Question 24

The linkages drawn below are most likely to be found in, respectively:







A. biodiesel, protein and carbohydrate
B. lipid, protein and glucose
C. fatty acid, amino acid and polysaccharide
D. lipid, protein and carbohydrate

Question 25

The reaction between glucose and fructose to form the disaccharide sucrose is best described as

A. a condensation reaction with the formation of an ether linkage.
B. a hydrolysis reaction with the formation of an ether linkage.
C. a condensation reaction with the formation of an ester linkage.
D. a hydrolysis reaction with the formation of an ester linkage.

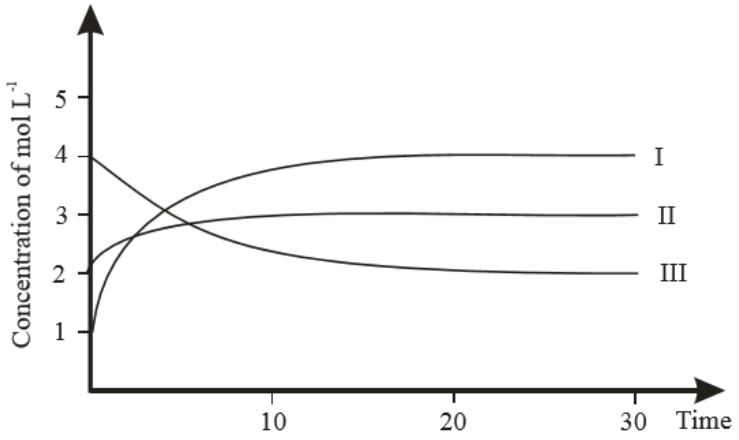
Question 26

Vitamins C and E are both essential vitamins. While the human body requires regular doses of vitamin C for good health, you can consume vitamin E less frequently. The reason for this is:

A. Vitamin C is essential but vitamin E can be produced by humans
B. Vitamin C is water soluble but vitamin E is fat soluble
C. Vitamin C is usually stored in fatty tissue and thus unavailable for metabolism by the human body
D. Vitamin E can be stored in the blood due to its solubility in water

Question 27

These graphs below show the concentrations for a mixture of gases, X, Y and Z which react and come to equilibrium according to the equation: $Y_{(g)} + 3Z_{(g)} \rightleftharpoons 2X_{(g)}$



Which of the graphs, I, II or III best represents the change in concentration of Y?

A. I

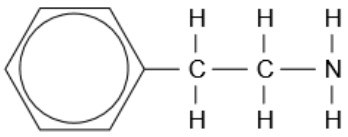
B. II

C. III

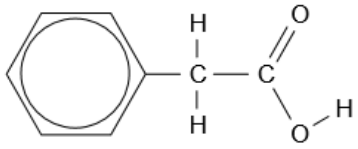
D. Cannot be determined on the basis of the information given.

Question 28

Phenylethylamine is a substance found in the human brain. A person in love has high levels of this chemical. A person with depression, however, has had much of their phenyethylamine converted to phenylacetic acid. The structures of both molecules are shown below.



phenylethylamine



phenylacetic acid

The conversion of phenylethylamine to phenylacetic acid occurs in two steps. Possible reagents causing these steps might be:

A. NaOH then $Cr_2O_7^{2-}/H^+_{(aq)}$

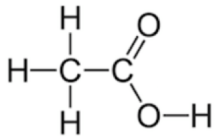
B. $Cr_2O_7^{2-}$ then NaOH

C. Cl_2 then NaOH

D. NaOH then NH_3

Question 29

The ethanoic acid molecule shown here will have:



	^{1}H NMR high resolution	Infrared spectrum cm^{-1}	Mass spectrum
A.	1 peak	2 peaks	3 peaks
B.	2 peaks with no splits	includes a peak at 3000 but not 1700	A base peak at 60
C.	2 peaks with no splits	includes a peak at 3000 and at 1700	includes a peak at 15 and at 45
D.	2 peaks, one a quartet and the other not split	includes a peak at 3000 and at 1700	includes a peak at 15 and at 29

Question 30

A 100 mL solution of glucose, $C_6H_{12}O_6$, has a concentration of 75.0 g L^{-1}. The number of glucose molecules in the solution is:

A. 0.0417
B. 0.417
C. 2.51×10^{22}
D. 2.51×10^{23}

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 marks 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

The equilibrium reaction between aqueous solutions of iron(III), $Fe^{3+}_{(aq)}$, and thiocyanate, $SCN^{-}_{(aq)}$ ions, is often investigated in VCE chemistry. The $Fe(NCS)^{2+}_{(aq)}$, produced in the reaction has a distinctive 'blood' red colour. The reaction referred to is

$$Fe^{3+}_{(aq)} + SCN^{-}_{(aq)} \rightleftharpoons Fe(NCS)^{2+}_{(aq)}$$

a. Write an expression for the equilibrium constant for this reaction.

b. In a practical investigation, two students mixed 4.00 mL of 2.00×10^{-3} M aqueous iron(III) nitrate and 2.00 mL of 2.00×10^{-3} M aqueous potassium thiocyanate solutions and allowed the mixture to reach equilibrium. They determined the concentration of the thiocyanate ion in the equilibrium mixture to be 7.87×10^{-5} M.

i. Calculate the concentrations of the iron(III) and thiocyanate ions in the mixture prior to any reaction occurring.

ii. Calculate the concentrations of the iron(III) and thiocyanate ions in the equilibrium mixture.

iii. Calculate the value of the equilibrium constant.

c. The students were then asked to determine the thermochemical nature, the sign of the enthalpy change, of the forward reaction.

i. Describe how the students could achieve this task.

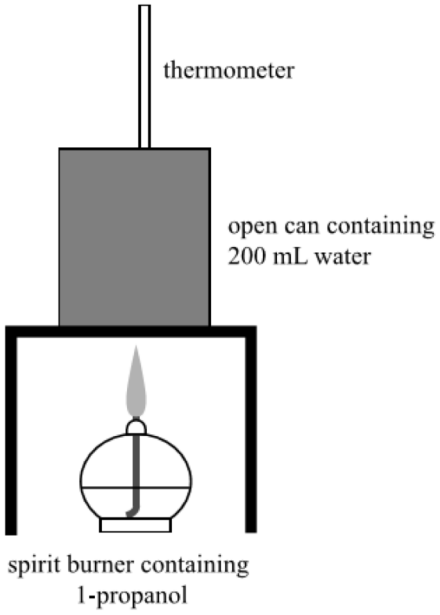
ii. What results would they expect to observe if the forward reaction was exothermic?

iii. What results would they expect to observe if the forward reaction was endothermic?

(1 + 2 + 2 + 1 + 2 + 1 + 1 = 10 marks)

Question 2

1-propanol is a common fuel burnt in some small, portable camping stoves. A laboratory experiment is set up to determine the heat of combustion of 1-propanol by burning some in a spirit burner and using the heat released to heat 200 mL of water. The equipment was set up as shown here.



The following data was recorded:

- Mass of spirit burner before heating: 125.62 g
- Mass of spirit burner after heating: 122.89 g
- Temperature of water before heating: 22.7°C
- Temperature of water after heating: 85.6°C

a. Use the change in the temperature of the water to determine the amount of energy, in kJ, added during heating.

b. Determine an experimental value of the enthalpy of combustion, in kJ mol^{-1}, of 1-propanol.

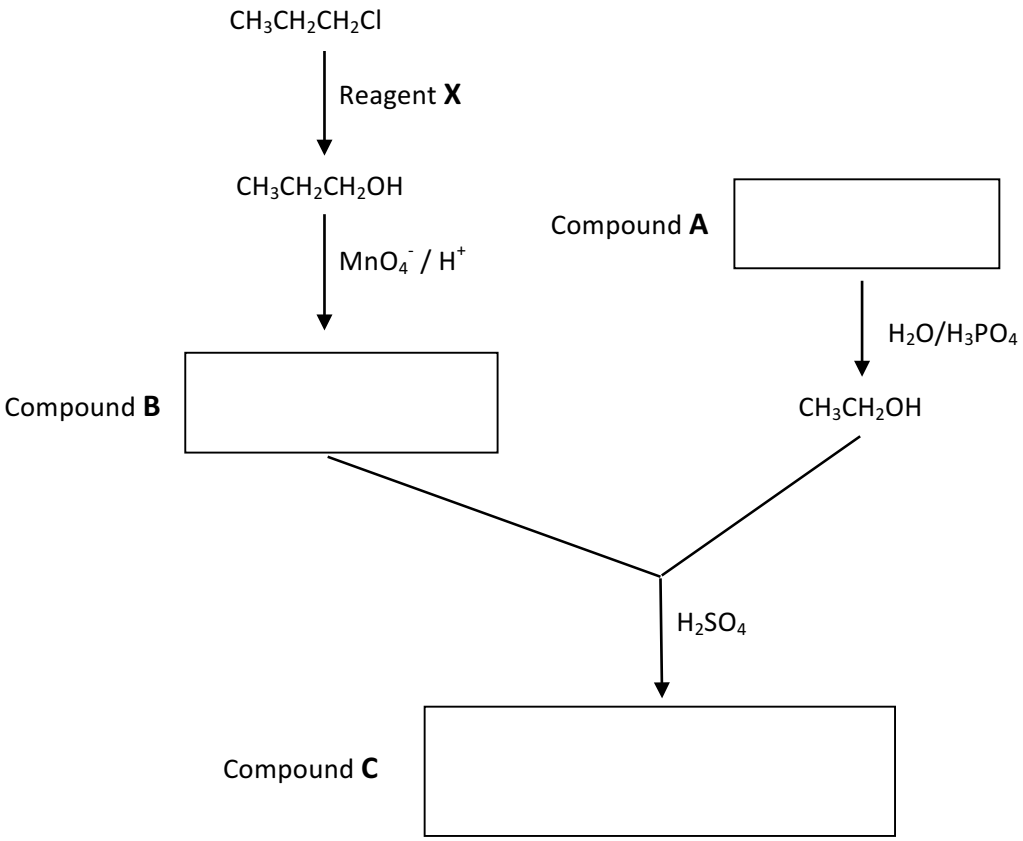
c. By comparing the experimentally determined value of the enthalpy of combustion with the theoretical one given in your data sheet, determine the percentage of chemical energy of the 1-propanol which ends up as heat energy in the water.

d. The molar enthalpy of combustion of 1-propanol has been accurately determined as -2016 $KJmol^{-1}$.
Give two reasons why the numerical value of the heat of combustion of 1-propanol obtained using the 'spirit burner' would be different to this value.

(2 + 2 + 1 + 2 = 7 marks)

Question 3

The reaction pathway below represents the synthesis of compound C.



a. Identify reagent X. _____

b. In the appropriate boxes above, write the semi-structural formulas for compounds A, B and C.

c. Give the systematic IUPAC names for compounds B and C.

compound B _____

compound C _____

(1 + 3 + 2 = 6 marks)

Question 4

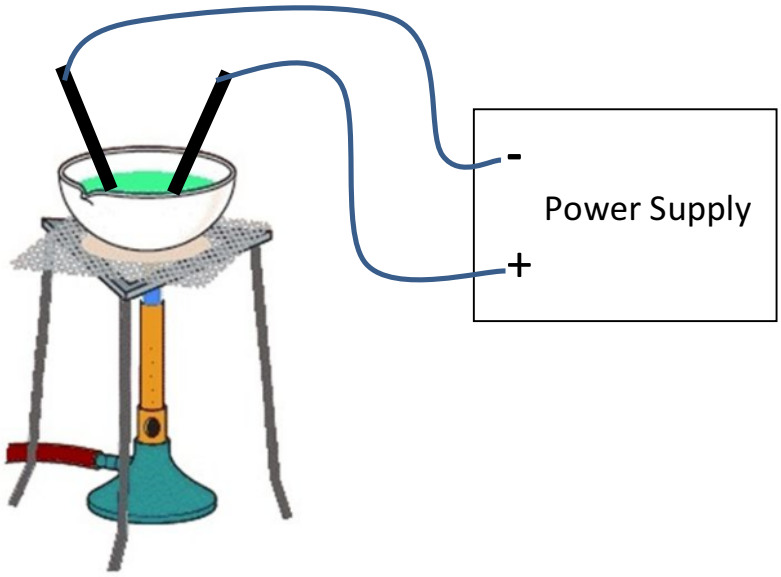
a. Draw the full structural formula of the amino acid which has the molecular formula $C_3H_7NO_2$. Clearly show all bonds.

b. The amino acid drawn in part a. can form two different dipeptides as a result of condensation reactions with the amino acid $C_2H_5NO_2$. Draw a structural formula of one of the dipeptides formed in the reaction between one molecule of each of these two amino acids.

(1 + 2 = 3 marks)

Question 5

The equipment shown in the diagram was set up to investigate electrolytic reactions. In one experiment the electrolyte used was molten magnesium chloride and the electrodes were made from platinum wire.



a. Write the chemical half-equation for the reaction that would occur at the positive electrode.

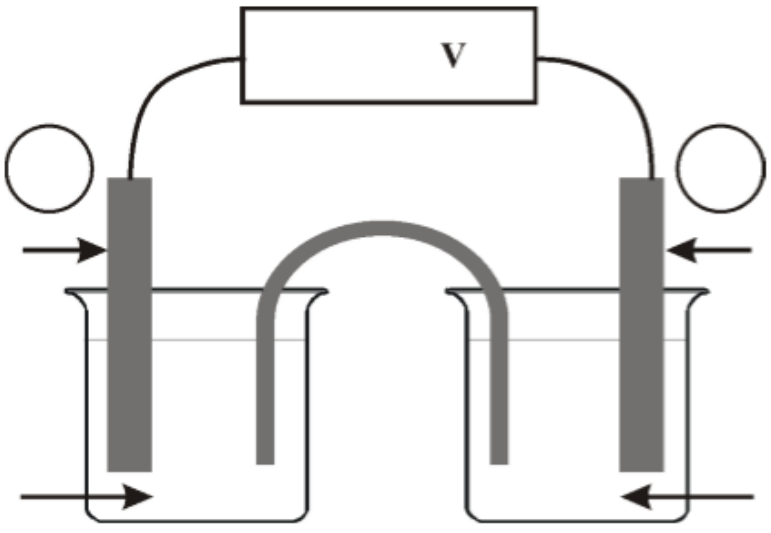
b. Write the chemical half-equation for the reaction that would occur at the negative electrode.

c. What would be the effects on the reactions occurring at these electrodes if iron were used in place of platinum?

d. What would be the effect on the products produced by replacing the molten magnesium chloride electrolyte used in the original set up, with a dilute aqueous solution of magnesium chloride, and discontinuing the heating?

e. A galvanic cell was constructed by combining the $I_{2\,(aq)}/I^-_{(aq)}$ and $Cu^{2+}_{\ (aq)}/Cu_{(s)}$ half-cells. On the diagram below indicate the following:

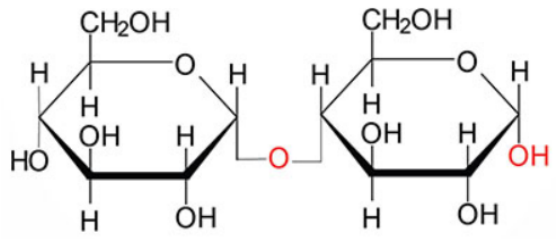
   i. the electrolytes used in the half-cells;
   ii. the composition of the electrodes;
   iii. the polarity of the electrodes when the cell is discharging,
   iv. the direction of e^- flow;
   v. the direction of ion flow in the salt bridge (using KNO_3), and
   vi. the theoretical voltage predicted by the standard half-cell E^0 values.



(1 + 1 + 1 + 2 + 6 = 11 marks)

Question 6

A structure for the disaccharide maltose ($C_{12}H_{22}O_{11}$) is given below



Maltose undergoes enzyme-catalysed hydrolysis during digestion.

a. Give the molecular formula of the product of this hydrolysis _____

b. Write a balanced equation for the combustion of one mole of maltose ($C_{12}H_{22}O_{11}$) in the presence of excess oxygen.

_____

_____

c. The monosaccharide from the hydrolysis of maltose also undergoes combustion in excess oxygen. Combustion of one mole of this monosaccharide releases 2816 kJ. Give a numerical estimate for the value of ΔH for the combustion of one mole of maltose and provide the reasoning for your estimate.

_____

_____

_____

_____

d. Most fats and oils contain the ester functional group formed by a condensation reaction between 1 molecule of glycerol and 3 molecules of fatty acids. How many hydrogen atoms are there in a molecule of a monounsaturated fatty acid with 16 carbon atoms?

_____

e. A potentially useful vehicle fuel is manufactured by a condensation reaction between one molecule of methanol (CH_3OH) and one molecule of a fatty acid. A particular fuel, methyl stearate, is produced when the fatty acid stearic acid ($C_{17}H_{35}COOH$) reacts with methanol. Write a balanced equation for the formation of methyl stearate from methanol and stearic acid.

_____

_____

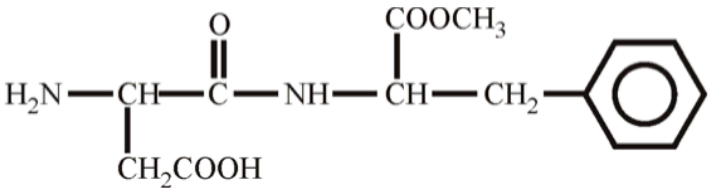
_____

(1 + 2 + 2 + 1 + 2 = 8 marks)

Question 7

Aspartame is an artificial sweetener used as a sugar substitute in a wide variety of foods and drinks. This molecule is approximately 200 times sweeter than sucrose (table sugar) and its structure is shown below.

a. On the diagram shown below, circle and clearly identify four different functional groups.



b. Name and draw the structures of the two amino acids produced when a molecule of aspartame is completely hydrolysed

c. A large number of proteins act as catalysts in metabolic processes in the human body. Compared to inorganic, industrial catalysts, enzymes are extremely specific in regard to the molecules they can react with.

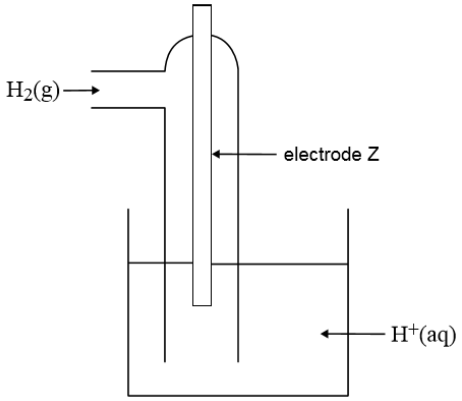
   i. Which aspect of the protein structure is largely responsible for the catalytic selectivity of enzymes?

   ii. Explain briefly why enzymes are very selective in their catalytic activity

(4 + 2 + 1 + 1 = 8 marks)

Question 8

The following diagram represents a $H^+_{(aq)}/H_{2\,(g)}$ half cell for the reaction $2H^+_{(aq)} + 2e^- \rightleftharpoons H_{2\,(g)}$



a. For this half cell, identify a suitable material to use for electrode Z. _____

b. For this half cell to be a standard half cell, what are the conditions under which it must operate?

_____

c. A galvanic cell consists of the following half cells which have been set up under standard conditions.

Half cell 1: the $H^+_{(aq)}/H_{2\,(g)}$ half cell described in part a.
Half cell 2: a cadmium (Cd) electrode in a solution containing $Cd^{2+}_{(aq)}$

After some time, there is an increase in the pH of Half cell 1. Which species in this galvanic cell must therefore be the stronger reductant and how did you reach this conclusion?

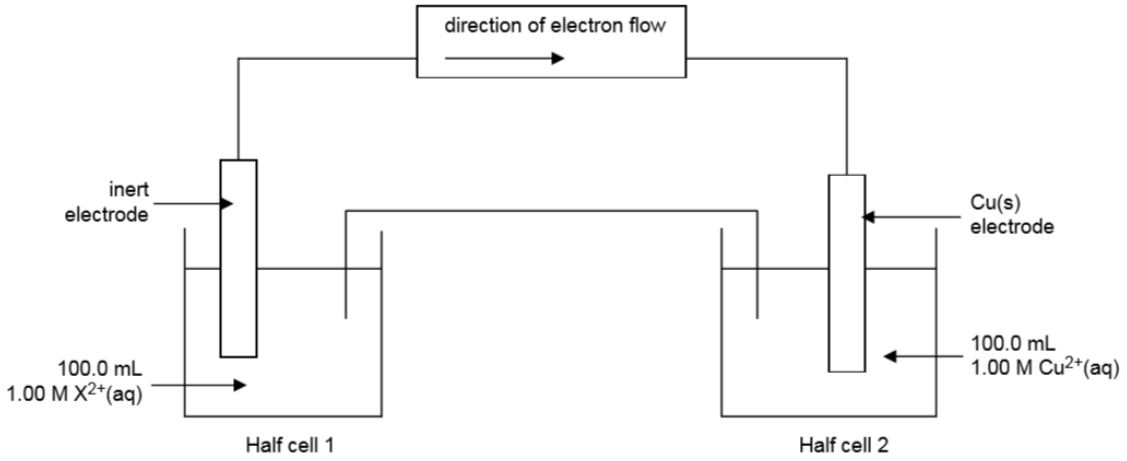
- The stronger reductant is _____
- Explanation _____

_____

_____

d. A second galvanic cell consists of the following half cells is set up.

Half cell 1: an inert electrode in 100.0 mL solution of 1.00 M $X^{2+}_{(aq)}$
Half cell 2: an electrode of $Cu_{(s)}$ in 100.0 mL solution of 1.00 M $Cu^{2+}_{(aq)}$



After discharging 18,500 Coulombs of electricity, the concentration of the $X^{2+}_{(aq)}$ in solution in half cell 1 was found to be 0.810 M. The volume of the solutions in the two half cells had not changed.

i. Calculate the amount, in mol, of $X^{2+}_{(aq)}$ that reacted in half cell 1.

_____

_____

_____

_____

ii. Calculate the ratio of $n(X^{2+})$ reacted : $n(e^-)$ that passed through the cell.

_____

_____

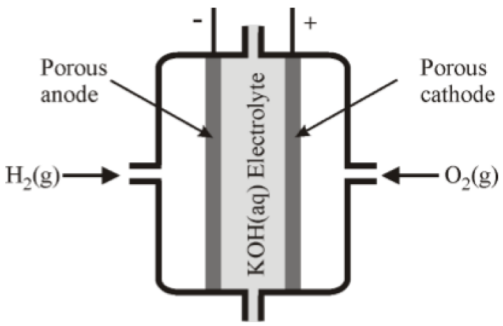
_____

iii. State the oxidation number of the product of the half reaction in half cell 1. _____

(1 + 1 + 2 + 2 + 2 + 1 = 9 marks)

Question 9

A diagram of an alkaline hydrogen/oxygen fuel cell is shown here. When generating a constant current this fuel cell consumes 6.8 L of hydrogen gas measured at SLC per hour.



a. Write an appropriate half-equation for the reaction occurring at the anode.

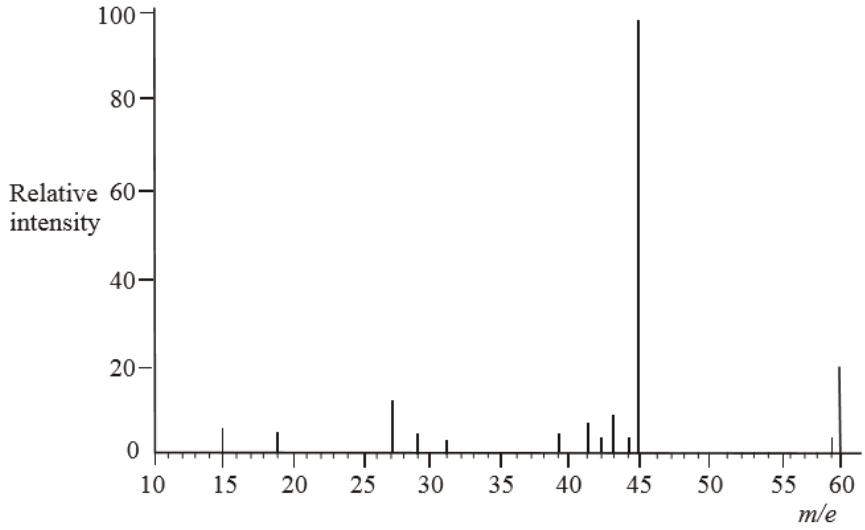
b. Calculate the amount, in mol, of hydrogen that the fuel cell consumes per hour.

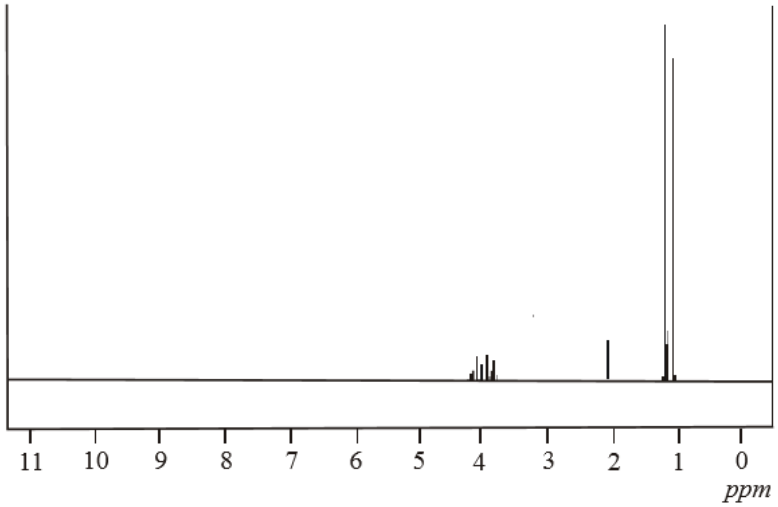
c. Calculate the current that this hydrogen gas consumption rate would produce, assuming that the cell was operating at 100 % efficiency.

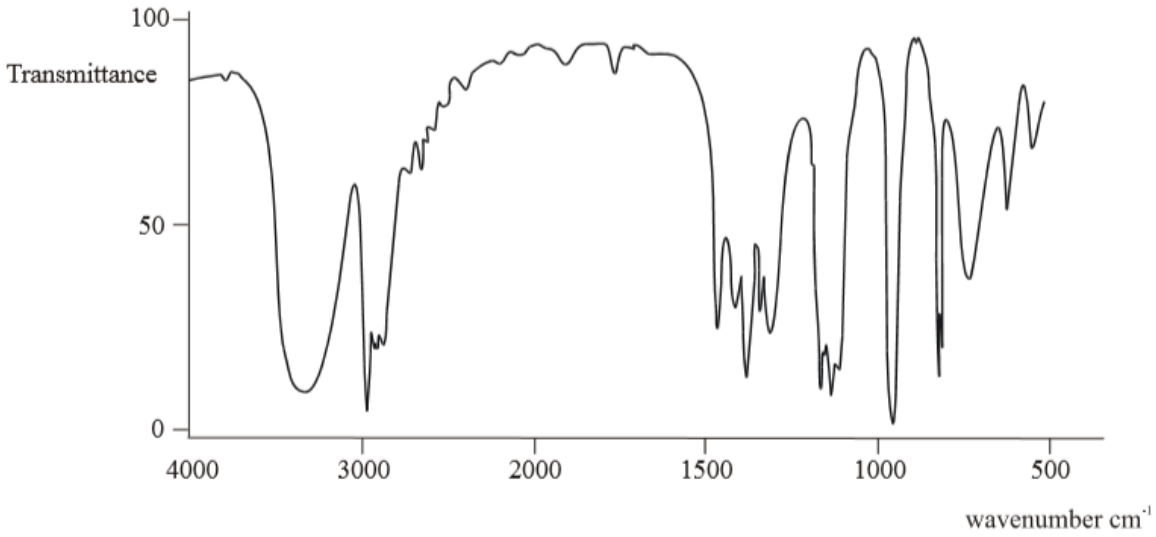
(1 + 1 + 2 + 2 + 2 + 1 = 9 marks)

Question 10

The identity and molecular structure of an organic compound is to be determined using a combination of mass, ^{1}H NMR, and IR spectra as shown below.







a. Using these 3 spectra, determine:

   i. the relative molecular mass of the compound.

   ii. the identity of any functional groups present in the compound.

   iii. the number of different hydrogen environments in the compound.

b. Determine the molecular formula of the compound.

c. Draw the full structural formulae for two compounds that have the molecular formula determined in (b) and contain the functional group identified in (a).

d. Explain how the NMR spectrum shown is consistent with one, but not both of the structures drawn in (c)

e. Give the name of the compound to which all three spectra apply

(1 + 1 + 1 + 1 + 2 + 2 + 1 = 9 marks)

END OF QUESTION AND ANSWER BOOK