CHEMOLOGY EDUCATION SERVICES

Name:_________________________

2013 CHEMISTRY Unit 3 & 4
TRIAL EXAM

Time allowed: 1 hour 30 minutes

QUESTION AND ANSWER BOOKLET

Structure of booklet

Section	Number of questions	Number of questions to be answered
A	30 multiple choice questions	30
B	13	13

Directions to students

Materials
Question and answer booklet of 38 pages.
Answer sheet for multiple choice questions.
An approved calculator may be used.
Data Booklet

The Task
Pleasure ensure that you write your name on the multiple choice answer sheet and this answer booklet.
Answer **all** items from Section A, which should be answered on the sheet provided.
Answer **all** questions from Section B, which should be answered in this booklet in the spaces provided.
There is a total of 142 marks available.
All answers should be written in English.

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SECTION A

Specific instructions for Section A

Question 1 consists of 30 multiple choice questions. Section A is worth approximately 22% of the marks available.

Choose the response that is **correct** or **best answers the question,** and mark your choice on the multiple choice answer sheet provided.

No credit will be given for an item if two or more letters are marked for that question. Marks will not be deducted for incorrect answers and you should attempt every question.

Question 1

Equal volumes and concentrations of hydrochloric acid and ethanoic acid are titrated with sodium hydroxide solutions of the same concentration. Which statement is correct?

A. The initial pH values of both acids are equal.
B. At the equivalence points, the solutions of both titrations have pH values of 7.
C. The same volume of sodium hydroxide is needed to reach the equivalence point.
D. The pH values of both acids increase equally until the equivalence points are reached.

Question 2

Which of the following statements about DNA is **not** correct?

A. DNA contains only the elements carbon, hydrogen, oxygen, nitrogen and phosphorous.
B. A piece of double-stranded DNA, which is 50 base pairs in length and contains 20 thymine bases, will also contain 20 guanine bases.
C. The bonding responsible for the primary structure of DNA is the same type of bonding as that responsible for the primary structure of proteins.
D. All DNA fragments are negatively charged.

Question 3

All the lead ions present in a 50.0 mL solution were precipitated by reaction with excess chloride ions. The mass of the dried precipitate was 0.595 g.
What was the concentration of lead in the original solution?

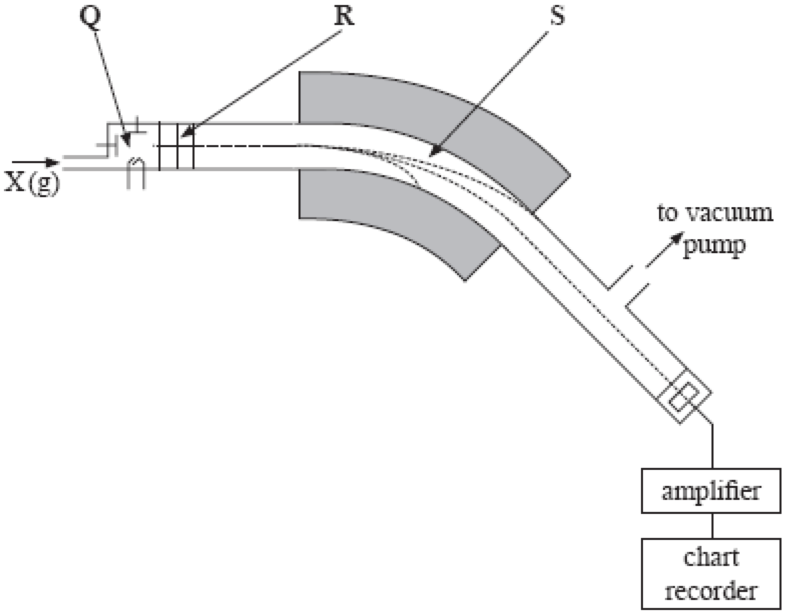
A 8.87 g L^{-1}
B 10.2 g L^{-1}
C 11.9 g L^{-1}
D 16.0 g L^{-1}

Question 4

What mass of anhydrous sodium carbonate is required to neutralise 100.0 mL of 0.500 M acetic acid?

A 2.65 g
B 5.30 g
C 10.6 g
D 53.0 g

A representation of a mass spectrometer is shown below.



Question 5

Which is the best description of the processes occurring at **Q**, **R** and **S** when element X (g) is analyzed?

	Q	R	S
A.	electric field applied	$X(g) + e^- \rightarrow X^+(g) + 2e^-$	magnetic field applied
B.	magnetic field applied	electric field applied	$X(g) + e^- \rightarrow X^+(g) + 2e^-$
C.	$X(g) + e^- \rightarrow X^+(g) + 2e^-$	electric field applied	magnetic field applied
D.	$X(g) + e^- \rightarrow X^+(g) + 2e^-$	magnetic field applied	electric field applied

Question 6
On analysis, a compound with molar mass 60 g mol^{-1} was found to contain 12 g of carbon, 2 g of hydrogen and 16 g of oxygen. What is the molecular formula of the compound?

A. CH_2O
B. CH_4O
C. C_2H_4O
D. $C_2H_4O_2$

Question 7
What happens when a few drops of bromine water are added to excess hex-1-ene and the mixture is shaken?

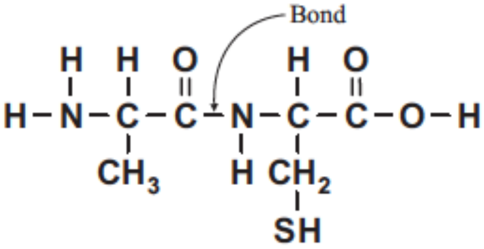
I. The colour of the bromine water disappears.
II. The organic product formed does not contain any carbon-carbon double bonds.
III. 2-bromohexane is formed.

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

Question 8
A sample of helium gas at 27 ºC has a volume of 80 L and a pressure of 4.0 atm. The temperature is increased to 47^0C, and the pressure is held at 4.0 atm. The volume will now be

A. 75 L
B. 85.3 L
C. 110 L
D. 139 L

Question 9
The structure below represents a biological molecule.



The specific type of covalent bond indicated is found in

A. fats.
B. esters.
C. proteins.
D. carbohydrates.

Question 10
When a sample absorbs radiowaves during NMR spectroscopy

A. electrons in atoms are promoted to higher energy levels.
B. nucleons are promoted to higher energy spin states.
C. molecules move to higher vibrational energy levels.
D. molecules are ionised.

Question 11
What is the pH of the solution formed when 0.085 moles NaOH is added to 1.00 L of 0.075M HCl ?

A. 2.00
B. 7.00
C. 12.00
D. 12.78

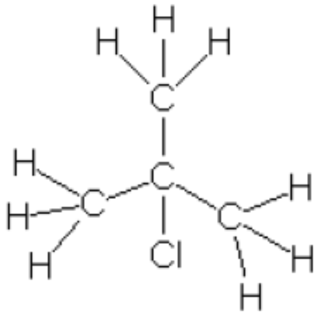
Question 12

Which of the following is a conjugate acid base pair?

	Acid	Conjugate base
A.	NH_4^+	NH_3
B.	H_3O^+	OH^-
C.	H_3PO_4	HPO_4^{2-}
D.	HPO_4^{2-}	$H_2PO_4^-$

Question 13

What is the correct systematic name for the following compound?

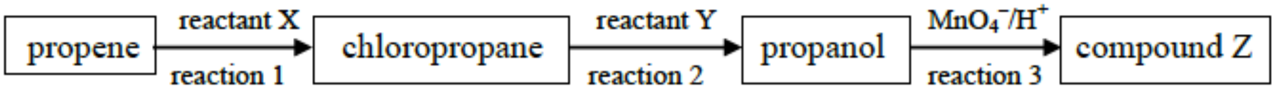


A. 2-methyl-chloropropane
B. 2-methyl-chlorobutane
C. 2-chloro-2-methylpropane
D. 2-chloro-2-methylbutane

Questions 14 & 15 refer to the following information

Question 14

Propene can be converted into other types of carbon compounds according to the following flow chart.



What could compounds X, Y and Z be, respectively?

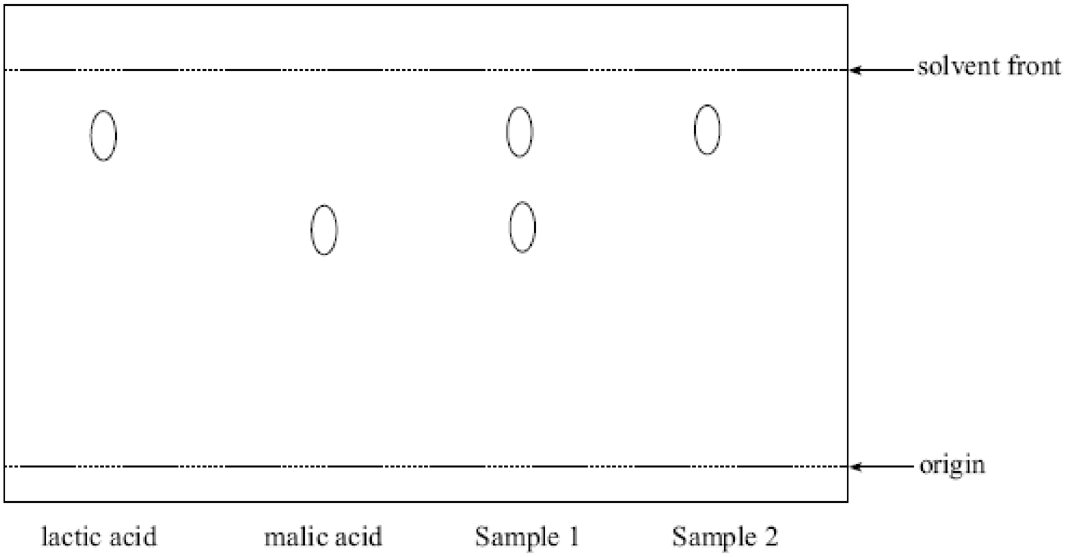
A. Cl_2, NaOH, propanoic acid
B. Cl_2, H_2O, propene
C. HCl, NaOH, propanoic acid
D. HCl, H_2O, propene

Question 15

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

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

A process known as malo-lactic fermentation occurs in some wines. During this process malic acid is converted into lactic acid. The extent of malo-lactic fermentation in one wine over a period of time was analysed by thin layer chromatography using a polar stationary phase.
Two samples of the wine were spotted onto the chromatography plate.
Reference samples of lactic acid and malic acid were also spotted onto the plate.
The chromatogram obtained is shown below:

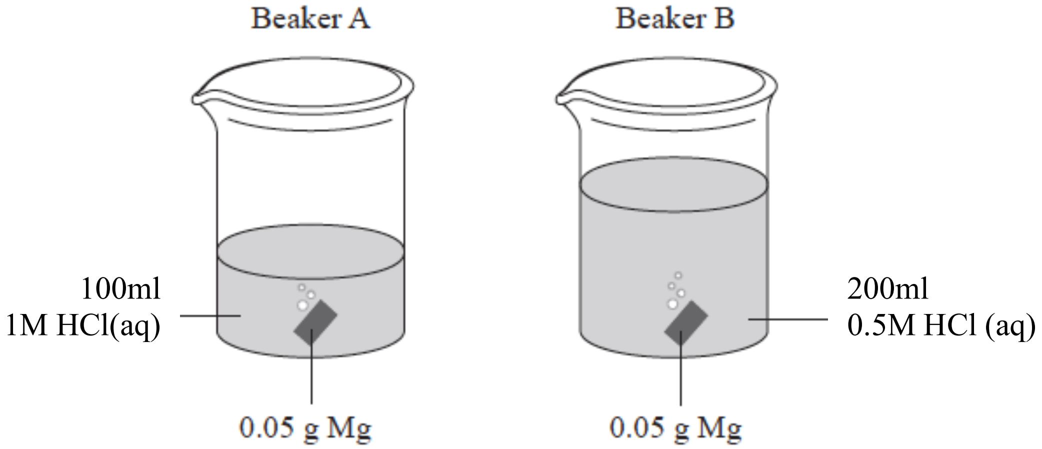


Question 16

Which one of the following is true?

A. Lactic acid adsorbs more strongly to the stationary phase than malic acid.
B. Malic acid has a larger R_f value than lactic acid.
C. Lactic acid is less soluble in the mobile phase than malic acid.
D. Malo – lactic fermentation had occurred in sample 2.

Identical pieces of magnesium are added to two beakers, A and B, containing hydrochloric acid. Both acids have the same initial temperature but their volumes and concentrations differ.



Question 17
Which statement is correct?

A. The maximum temperature in A will be higher than in B.
B. The maximum temperature in A and B will be equal.
C. It is not possible to predict whether A or B will have the higher maximum temperature.
D. The temperature in A and B will increase at the same rate.

Question 18
What effect does a catalyst have on a reaction?

A. It increases the rate.
B. It increases the yield.
C. It increases the heat of reaction.
D. It increases the activation energy.

Question 19
A sample of distilled water is placed in a calorimeter. The water is at 18.0 °C.
0.10 g of methanol, CH_3OH, is burnt in the calorimeter and the temperature rises to 28.0 °C.
The calibration factor for the calorimeter is, in kJ°C^{-1}. ($\Delta H_{\text{methanol}} = -715$ kJmol^{-1})

A. 113
B. 0.223
C. 454
D. -454

Consider the following two reactions:

I	$2Na_3PO_4(aq) + 3CuCl_2(aq) \rightarrow Cu_3(PO_4)_2(s) + 6NaCl(aq)$
II	$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

Question 20

Which of the following would increase the rate of reaction II but not of reaction I?

A. adding a suitable catalyst
B. increasing the surface area of a reactant
C. increasing the concentration of a reactant
D. increasing the temperature of the reactants

Question 21

A pure aluminium block with a mass of 10 g is heated so that its temperature increases from $20^{o}C$ to 50^{o} C . The specific heat capacity of aluminium is 8.99×10^{-1} J g^{-1} K^{-1} . Which expression gives the heat energy change in kJ?

A. $10\times8.99\times10^{-1}\times303$

B. $10\times8.99\times10^{-1}\times30$

C. $\dfrac{10\times8.99\times10^{-1}\times303}{1000}$

D. $\dfrac{10\times8.99\times10^{-1}\times30}{1000}$

Question 22
Consider the following equilibrium:

$$N_2H_6CO_2\ (g) \longleftrightarrow CO_2\ (g) + 2NH_3\ (g)$$

Which of the following is the correct expression for the equilibrium constant?

A. $K_{eq} = [CO_2][NH_3]$

B. $K_{eq} = [CO_2][NH_3]^2$

C. $K_{eq} = \frac{[CO_2][NH_3]^2}{[N_2H_6CO_2]}$

D. $K_{eq} = \frac{1}{[CO_2][NH_3]^2}$

The next two questions refer to the following information

$$Ni(s) + 4CO(g) \leftrightarrows Ni(CO)_4(g) \qquad \Delta H = -603\ kJ$$

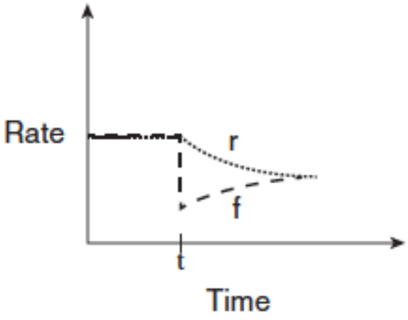
Question 23
Which of the following describes what happens when the temperature is increased?

	Equilibrium shift	[CO]
A.	left	increases
B.	left	decreases
C.	right	increases
D.	right	decreases

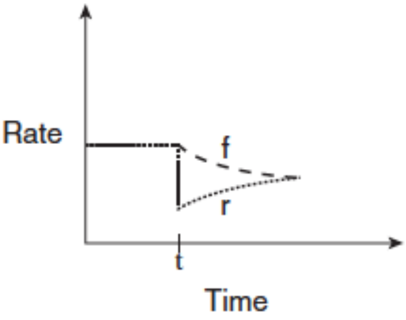
Question 24

Which graph represents the changes in the forward and reverse reaction rates when $Ni(CO)_4$ is removed from the above equilibrium at time t?

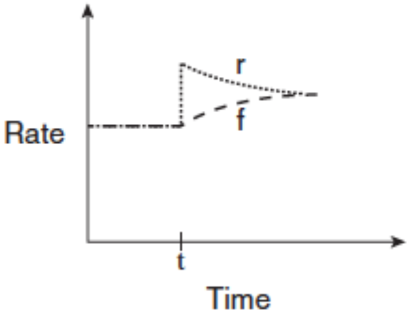
A.



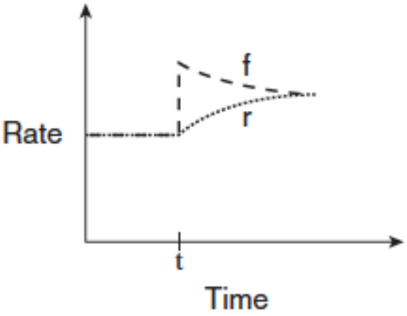
B.



C.



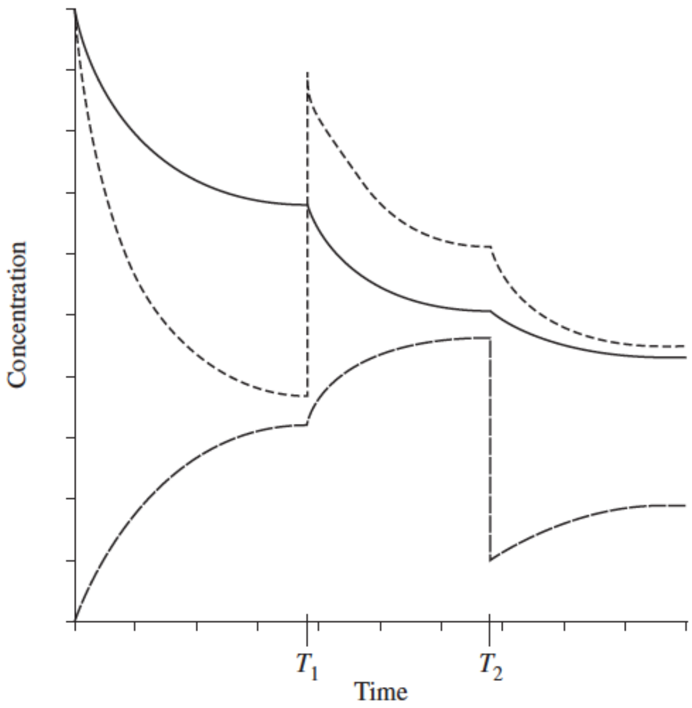
D.



Question 25

The graph shows the concentrations over time for the system:

$$CO(g) + 2H_2(g) \leftrightarrow CH_3OH(g)$$



What has happened at times T_1 and T_2?

	T_1	T_2
(A)	H_2 added	CH_3OH removed
(B)	CO added	CH_3OH removed
(C)	H_2 added	CO removed
(D)	CO added	CO and H_2 removed

Question 26

Consider the following equilibrium:

$$SO_3\,(g) + 6HF(g) \longleftrightarrow SF_6\,(g) + 3H_2O(g) \qquad Keq = 6.3 \times 10^{-3}$$

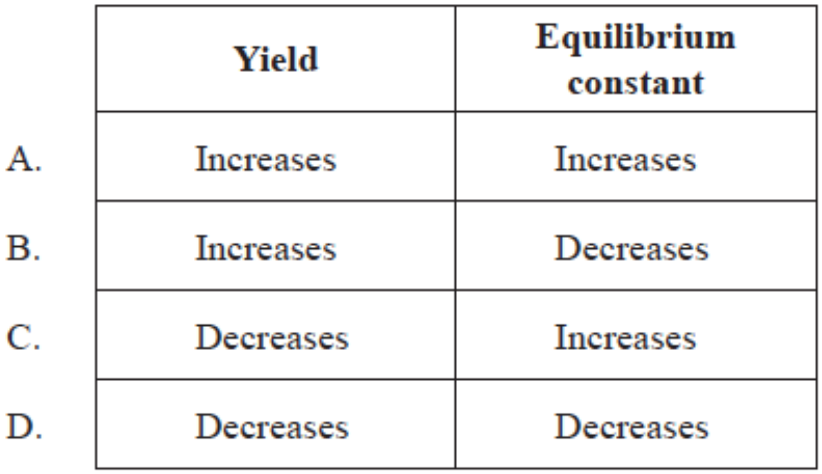
A 3.0 L flask contained 1.20 mol SO_3 , 0.30 mol HF and 1.50 mol SF_6 at equilibrium.
How many moles of H_2O were present?

A. 1.5×10^{-8} mol
B. 1.7×10^{-3} mol
C. 5.0×10^{-9} mol
D. 5.1×10^{-3} mol

Question 27

What is the effect of an increase of temperature on the yield and the equilibrium constant for the following reaction?

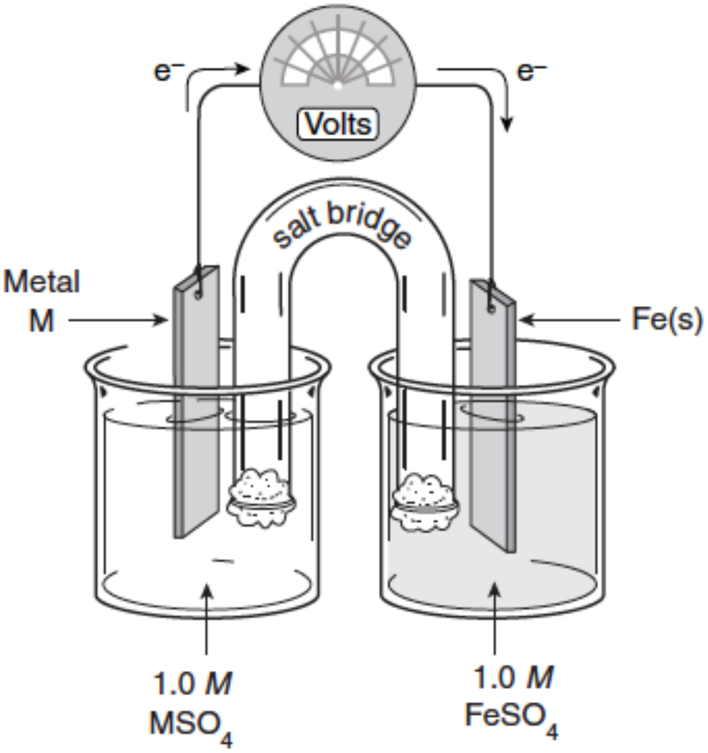
$$2H_2\,(g) + CO(g) \longleftrightarrow CH_3OH(l) \qquad \Delta H = -128 \text{ kJ mol}^{-1}$$



	Yield	Equilibrium constant
A.	Increases	Increases
B.	Increases	Decreases
C.	Decreases	Increases
D.	Decreases	Decreases

Question 28

Consider the following electrochemical cell:



The identity of the metal at M and the reading on the voltmeter are:

	Metal M	Voltage
A	Zinc	+0.32 V
B	Tin	+0.32 V
C	Zinc	+1.20 V
D	Tin	+0.59 V

Question 29

A voltaic cell is made by connecting two half-cells represented by the half-equations below:

$Mn^{2+}\ (aq) + 2e^- \rightarrow Mn\ (s) \qquad E^0 = -1.19\ V$

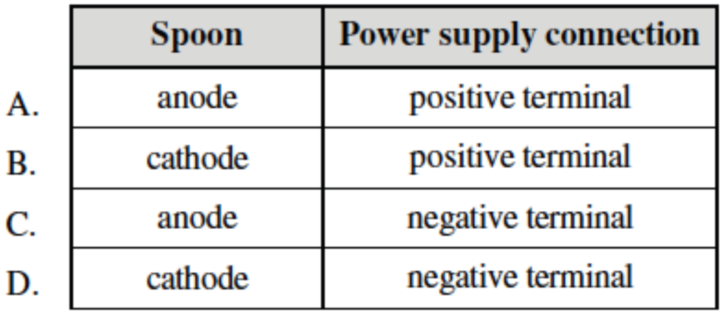
$Pb^{2+}\ (aq) + 2e^- \rightarrow Pb\ (s) \qquad E^0 = -0.13\ V$

Which statement is correct about this voltaic cell?

A. Mn is oxidized and the voltage of the cell is 1.06 V.
B. Pb is oxidized and the voltage of the cell is 1.06 V.
C. Mn is oxidized and the voltage of the cell is 1.32 V.
D. Pb is oxidized and the voltage of the cell is 1.32 V.

Question 30

A metal spoon is to be electroplated with silver using a DC power supply. Which of the following is correct?



	Spoon	Power supply connection
A.	anode	positive terminal
B.	cathode	positive terminal
C.	anode	negative terminal
D.	cathode	negative terminal

END OF SECTION A

SECTION B

Specific Instructions for Section B

Section B consists of 13 short answer questions (question 1 to 13). You must answer all of these questions. The section is worth 112 marks or approximately 78% of the total.

Questions should be answered in the spaces provided in this booklet.

You should

* give simplified answers with the appropriate number of significant figures. Unsimplified answers will not receive full marks.

* Show all working in your answers to numerical problems. No marks can be given unless accompanied by working.

* make sure all chemical equations are balanced and that formulas for individual substances include an indication of state. Eg $H_2(g)$, NaCl (s).

Question 1 (14 marks)

Butan-1-ol, butan-2-ol, 2-methylpropan-1-ol and 2-methylpropan-2-ol are four structural isomers with the molecular formula $C_4H_{10}O$.

Details of the ^1H NMR spectra of two of these alcohols are given below.

Spectrum 1

Two peaks:

One at 1.3 ppm (relative to the TMS reference) with an integration trace of nine units, and the other at 2.0 ppm with an integration trace of one unit.

Spectrum 2

Four peaks: The first at 0.9 ppm with an integration trace of six units.

The second at 1.7 ppm with an integration trace of one unit.

The third at 2.1 ppm with an integration trace of one unit.

The fourth at 3.4 ppm with an integration trace of two units.

a) Consider the proton environments present in each of the alcohol molecules when answering the following questions.

(i) Identify which alcohol gives spectrum 1 and explain your answer by stating which hydrogen atoms in the molecule are responsible for each of the two peaks. [3 marks]

(ii) Deduce which alcohol gives spectrum 2. Explain which particular hydrogen atoms in the molecule are responsible for the peaks at 0.9 ppm and 3.4 ppm. [3 marks]

b) The mass spectrum of one of the alcohols shows peaks at m/z values of 74, 59 and 45.

(i) Deduce which two of the alcohols could produce this spectrum and identify the species responsible for the three peaks. [4 marks]

(ii) The spectrum also shows a significant peak at m/z = 31. Suggest which alcohol is responsible for this spectrum and deduce the species responsible for the peak at m/z = 31. [2 marks]

(c) Explain why the infrared spectra of all four alcohols are very similar. [2 marks]

Question 2 (12 marks)

The percentage by mass of calcium carbonate in eggshell was determined by adding excess hydrochloric acid to ensure that all the calcium carbonate had reacted. The excess acid left was then titrated with aqueous sodium hydroxide.

(a) A student added 27.20 ml of 0.200M HCl to 0.188 g of eggshell. Calculate the amount, in mol, of HCl added. (1 mark)

(b) The excess acid requires 23.80 ml of 0.100 M NaOH for neutralization.
Calculate the amount, in mol, of acid that is in excess. (2 marks)

(c) Determine the amount, in mol, of HCl that reacted with the calcium carbonate in the eggshell. (2 marks)

(d) State the equation for the reaction of HCl with the calcium carbonate in the eggshell. (2 marks)

(e) Determine the amount, in mol, of calcium carbonate in the sample of the eggshell. (2 marks)

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(f) Calculate the mass and the percentage by mass of calcium carbonate in the eggshell sample. (2 marks)

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(g) Deduce one assumption made in arriving at the percentage of calcium carbonate in the eggshell sample. (1 mark)

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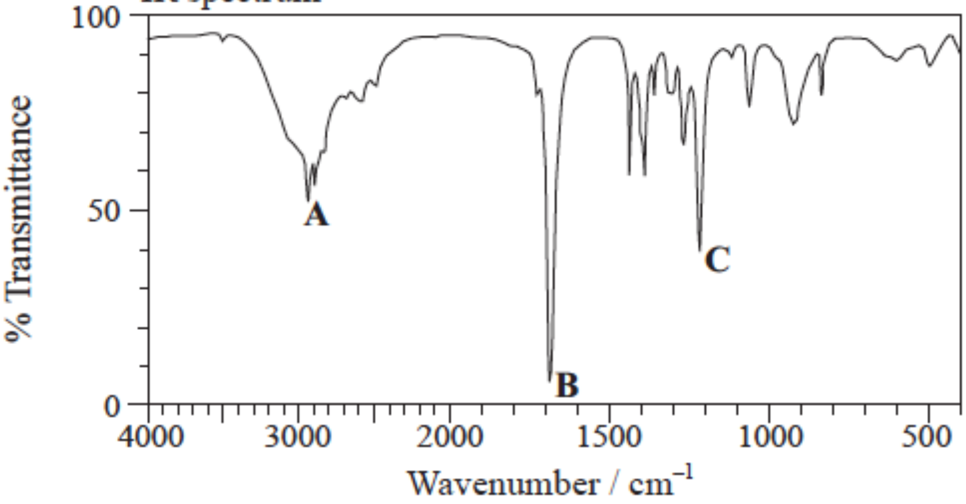
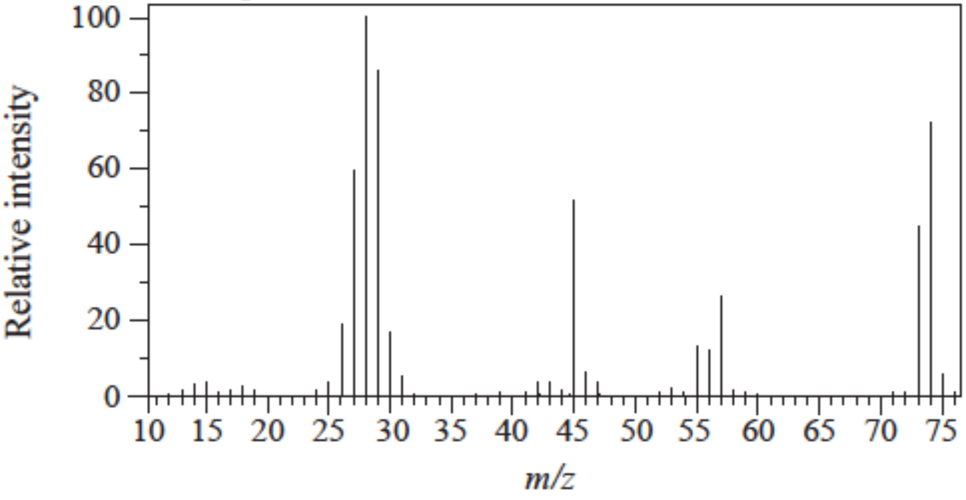
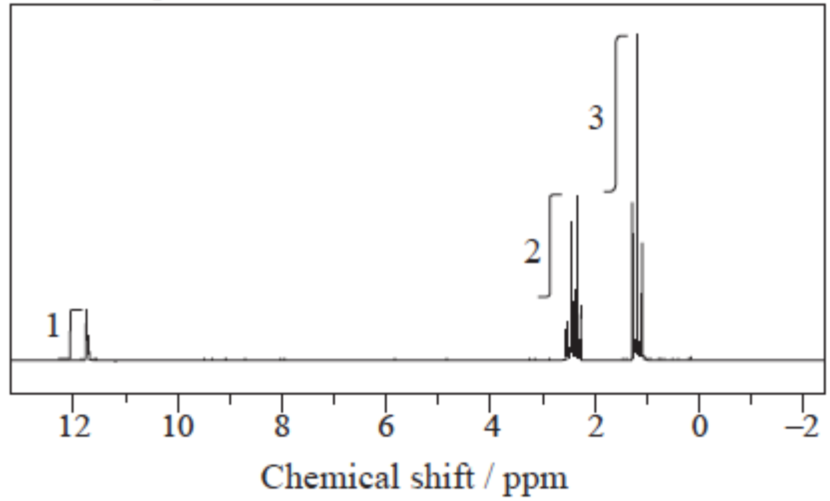
Question 3 (8 marks)
The IR spectrum, mass spectrum and ^1H NMR spectrum of an unknown compound, **X**, of molecular formula $C_3H_6O_2$ are as follows.


IR spectrum


Mass spectrum


^1HNMR spectrum

a) Identify the bonds responsible for the peaks **A**, **B** and **C** in the IR spectrum of **X**. (2 marks)

A: ____

B: ____

C: ____

b) In the mass spectrum of **X**, deduce which ions the *m/z* values at 74, 45 and 29 correspond to. (3 marks)

m/z = 74: ____

m/z = 45: ____

m/z = 29____

c) Identify the peak at 11.73 ppm in the ^{1}H NMR spectrum. (1 mark)

____

d) Deduce the structure of **Y**. (1 mark)

e) Explain why tetramethylsilane (TMS) is suitable as a reference standard. (1 mark)

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Question 4 (15 marks)
Chloroethene, C_2H_3Cl, is an important organic compound used to manufacture the polymer poly(chloroethene).

a) i) Draw the structural formula for chloroethene and predict the H – C– Cl bond angle. (1 mark)

ii) Draw a section of poly(chloroethene) containing six carbon atoms. (1 mark)

iii) Outline why the polymerization of alkenes is of economic importance and why the disposal of plastics is a problem. (2 marks)

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b) Chloroethene can be converted to ethanol in two steps. For each step deduce an overall equation for the reaction taking place.

Step 1: (1 mark)

____

Step 2: (1 mark)

____

c) i) Ethanol can be produced by the fermentation of glucose. Write the equation for the fermentation of glucose to produce ethanol. (2 marks)

____

ii) Describe the fermentation process, explaining two of the reaction conditions necessary. (1 mark)

____

____

d) State the reagents and conditions necessary to prepare ethanoic acid from ethanol in the laboratory. (2 marks)

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e) State an equation, including state symbols, for the reaction of ethanoic acid with water. Identify a Brønsted-Lowry acid in the equation and its conjugate base. (2 marks)

____

Brønsted-Lowry acid __________________________ (2 marks)

Conjugate Base _______________________________

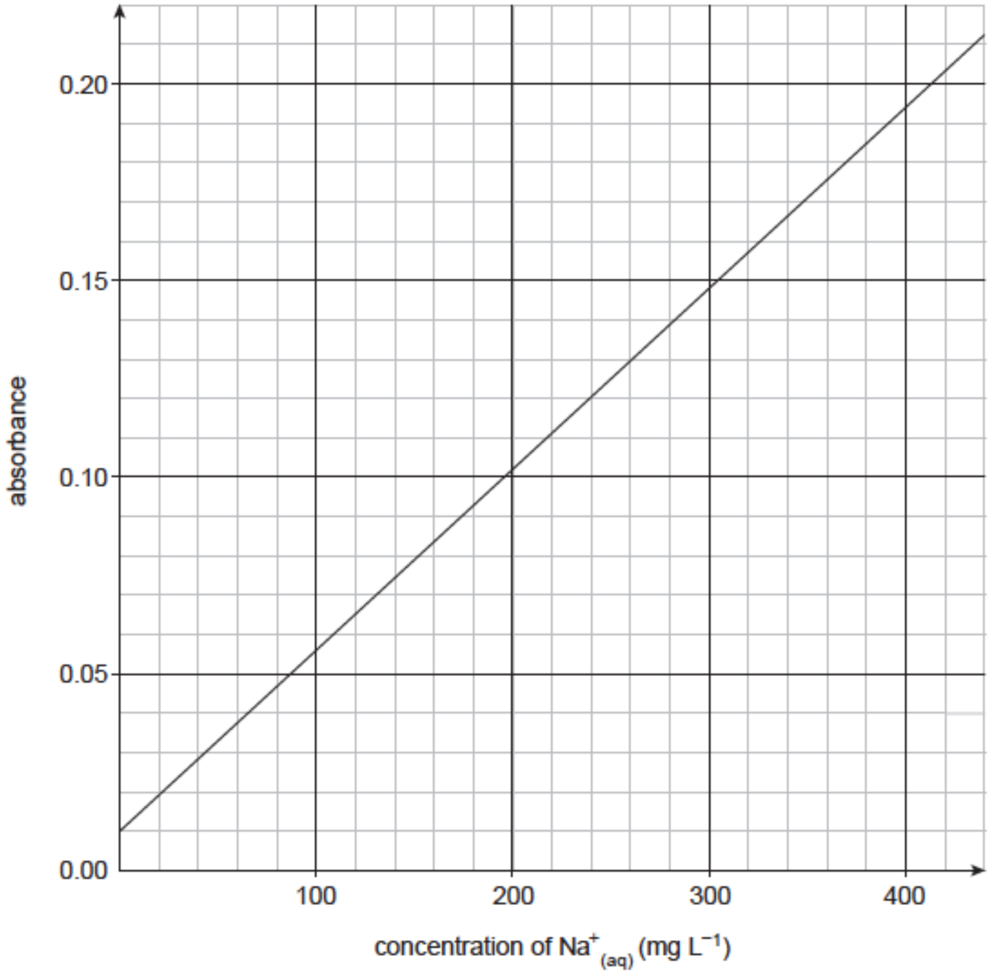
Question 5 (5 marks)

Sodium chloride is commonly found in food. The concentration of the sodium and chloride ions can be determined in a number of ways.

Atomic absorption spectroscopy (AAS) was used to determine the sodium content of a sample of tomato sauce.

Solutions with known concentrations of sodium ions were prepared for use in this determination.

The solutions of known concentration were used in constructing the calibration graph shown below:



a) Suggest why the calibration line does not pass through the origin. (1 mark)

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b) Explain why the presence of calcium ions in the sauce would not affect the measurement of the concentration of sodium ions by AAS. (2 marks)

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c) A 25.00 mL sample of the sauce was diluted to 500.0 mL with distilled water. The diluted sample was found to have an absorbance of 0.165.
Using the calibration graph on the previous page, determine the concentration (in mg L^{-1}) of sodium ions in the undiluted sauce. (2 marks)

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Question 6 (18 marks)

Individual 2-amino acids have different structures depending on the pH of the solution they are dissolved in. The structures of serine and cysteine are given in the Data Booklet.

(a) Deduce the structure of serine in

(i) a solution with a pH of 2. (2 marks)

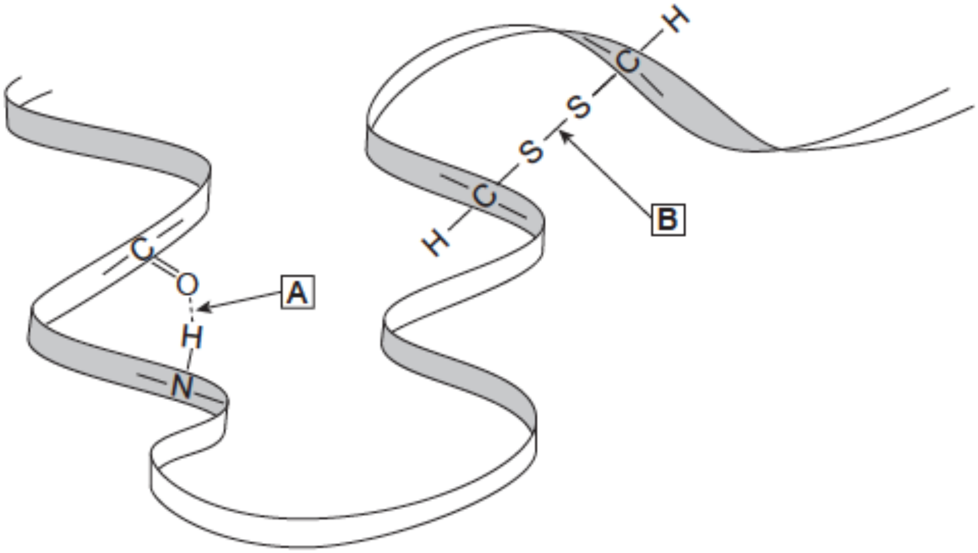
(ii) a solution with a pH of 12. (2 marks)

(b) Deduce the structure of serine in pH of 7. (2 marks)

(c) Deduce the structures of the two different dipeptides that can be formed when one molecule of serine reacts with one molecule of cysteine. (2 marks)

(d) The tertiary structures of proteins made up of 2-amino acid residues such as serine and cysteine, are the result of interactions between amino acids to give a three-dimensional shape. State five different types of interaction that can occur, in each case identify the atoms or groups joined together. (5 marks)

Some of the interactions between atoms in an invertase molecule are shown in the diagram below:



e) Name the types of interactions labelled A and B .

A is

____

B is ____ (2 marks)

(ii) State which interaction is stronger, A or B .

____ (1 mark)

(iii) Explain why a change of pH may affect the action of the invertase enzyme. (2 marks)

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Question 7 (6 marks)

In an experiment to measure the enthalpy change of combustion of ethanol, a student heated a copper calorimeter containing 100 cm3 of water with a spirit lamp and collected the following data.

Initial temperature of water: 20.0^{o} C
Final temperature of water: 55.0^{o} C
Mass of ethanol burned: 1.78 g
Density of water: 1.00 g ml^{-1}

a) Use the data to calculate the heat evolved when the ethanol was combusted. [2 marks]

____

____

____

b) Calculate the enthalpy change of combustion per mole of ethanol. [2 marks]

____

____

____

c) Suggest two reasons why the result is not the same as the value in the Data Booklet. [2 marks]

____

____

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Question 8 (4 marks)

Honey bees obtain energy from the aerobic respiration of glucose.

a) Write an equation for the aerobic respiration of glucose. (2 marks)

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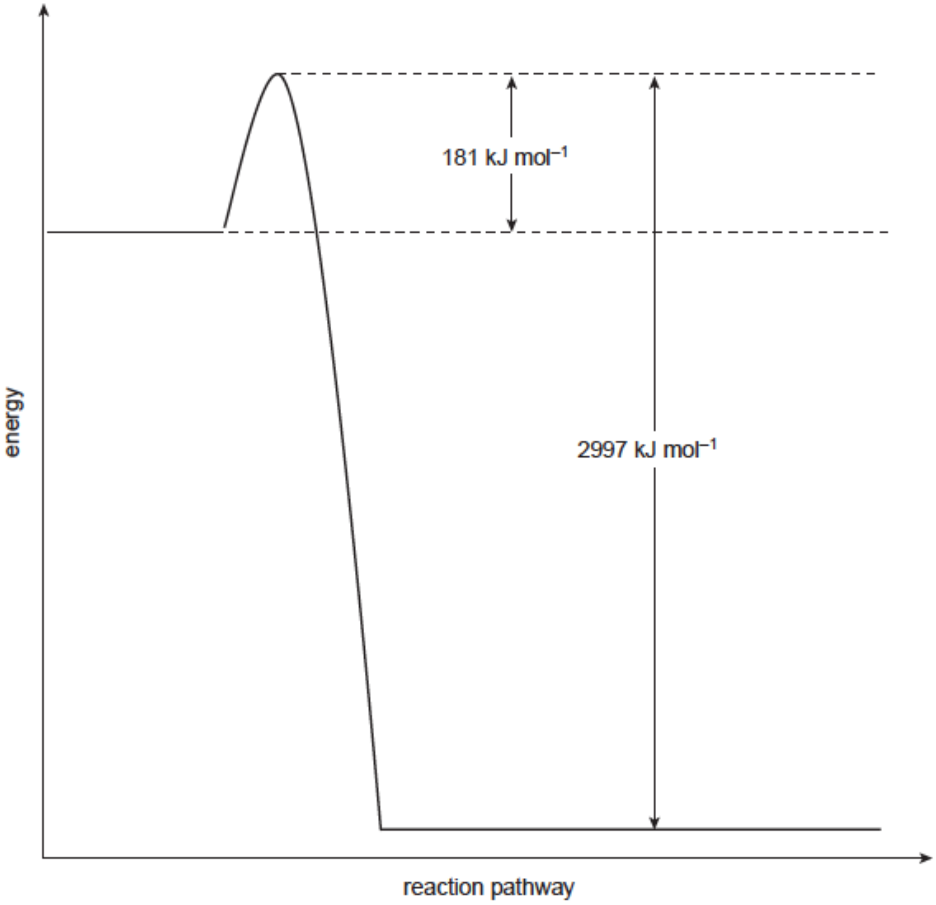
The energy changes associated with the aerobic respiration of glucose are shown in the energy diagram below:



b) Using the energy diagram above, determine the enthalpy change for the aerobic respiration of glucose. (2 marks)

ΔH = ______________________________kJ mol^{-1}

Question 9 (6 marks)

The silver content of a silver alloy can be determined as follows:

Take shavings from the alloy and completely dissolve them in nitric acid to obtain an aqueous solution of silver nitrate. Add an aqueous solution of sodium chloride to the silver nitrate solution until all the silver is precipitated as silver chloride.

In an experiment, a mass of 1.56 g of silver alloy shavings gave a precipitate of 1.57 g.

a) Write an equation for the reaction of sodium chloride and silver nitrate. (1 mark)

b) Determine the amount of, in mol, of silver chloride. (2 marks)

c) Determine the percentage, by mass, of silver in the alloy. (3 marks)

Question 10 (4 marks)

Consider the following equilibrium:

$$CH_4\,(g) + 2H_2S(g) \leftrightarrow CS_2\,(g) + 4H_2\,(g)$$

Initially, 0.120 mol CH_4 and 0.280 mol H_2S were placed in a 2.00 L flask. At equilibrium, [CS_2]= 0.030M. Calculate Keq .

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Question 11 (5 marks)

A 2.00 M diprotic acid (H_2X) has a pH of 0.60. Calculate its Ka value.

Question 12 (8 marks)
A 0.05 mol L^{-1} solution of sodium chloride was electrolysed using graphite electrodes. Separate pieces of litmus paper were dipped into the solution directly next to each electrode.
The following observations were made:

Polarity of electrode	Observation	Colour of litmus paper
Positive	Bubbles	Red
Negative	Bubbles	Blue

a) Draw and label a diagram to represent this cell. (2 marks)

b) Account for the observations and colour of litmus paper at the anode and cathode. Include relevant chemical equations in your answer. (4 marks)

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c) What is the difference between the electrolytic cell described above and a galvanic cell, in terms of energy requirements and conversions? (2 marks)

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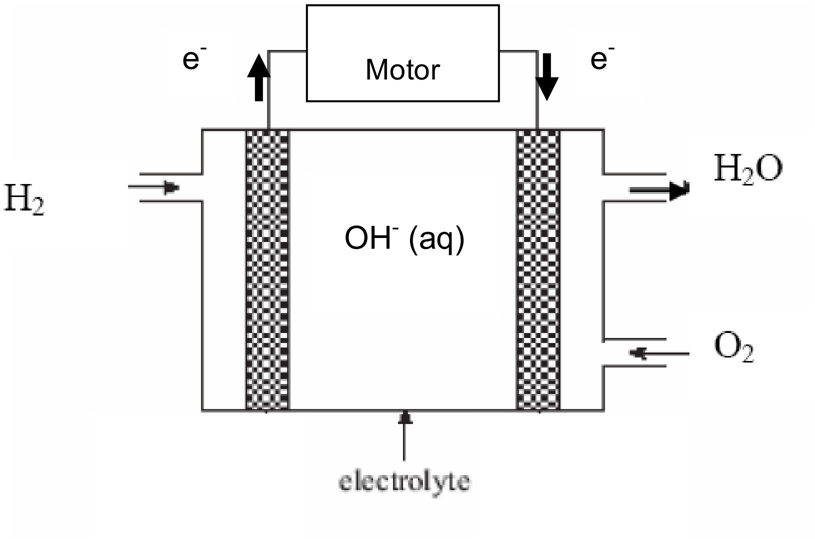
Question 13 (9 marks)

Car makers are quite well advanced in the development of fuel cells for cars using hydrogen gas as the main fuel. A simplified diagram is shown below:



The fuel cell consists of two sections: hydrogen gas is pumped through one half and oxygen gas the other. The two halves are joined and an alkaline electrolyte such as KOH passes through the middle. The electrodes consist of a porous nickel alloy mesh.

a) Write balanced ionic half equations for the reactions occurring at the anode and cathode. (2 marks)

Anode ____

Cathode____

b) i) State **two** roles of the nickel electrodes. (2 marks)

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Question 13 continued

ii) Given that the cost of building an engine to run on hydrogen is significantly greater than petrol engines, give **two** advantages of using these cells over petrol engines. (2 marks)

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c) A particular fuel cell generated 7.82 A for 2.00 hours. Calculate the volume of hydrogen gas required at a pressure of 3000 kPa and a temperature of 200^0C during this time. (3 marks)

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END OF EXAM

Physical constants

$F = 96\ 500\ \text{C mol}^{-1}$

$R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$

1 atm = 101 325 Pa = 760 mmHg

0°C = 273 K

Molar volume at STP = 22.4 L mol^{-1}

Avogadro constant = $6.02 \times 10^{23}\ \text{mol}^{-1}$

Ideal gas equa

$pV = nRT$

The electrochemical series

	E° in volt
$F_2(g) + 2e^- \rightarrow 2F^-(aq)$	+2.87
$H_2O_2(aq) + 2H^+(aq) + 2e^- \rightarrow 2H_2O(l)$	+1.77
$Au^+(aq) + e^- \rightarrow Au(s)$	+1.68
$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$	+1.36
$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$	+1.23
$Br_2(l) + 2e^- \rightarrow 2Br^-(aq)$	+1.09
$Ag^+(aq) + e^- \rightarrow Ag(s)$	+0.80
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+0.77
$I_2(s) + 2e^- \rightarrow 2I^-(aq)$	+0.54
$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$	+0.40
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34
$S(s) + 2H^+(aq) + 2e^- \rightarrow H_2S(g)$	+0.14
$2H^+(aq) + 2e^- \rightarrow H_2(g)$	0.00
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$	–0.13
$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$	–0.14
$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$	–0.23
$Co^{2+}(aq) + 2e^- \rightarrow Co(s)$	–0.28
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	–0.44
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	–0.76
$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	–0.83
$Mn^{2+}(aq) + 2e^- \rightarrow Mn(s)$	–1.03
$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$	–1.67
$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$	–2.34
$Na^+(aq) + e^- \rightarrow Na(s)$	–2.71
$Ca^{2+}(aq) + 2e^- \rightarrow Ca(s)$	–2.87
$K^+(aq) + e^- \rightarrow K(s)$	–2.93
$Li^+(aq) + e^- \rightarrow Li(s)$	–3.02

Periodic table of the elements

1 **H** 1.0																	2 **He** 4.0
3 **Li** 6.9	4 **Be** 9.0											5 **B** 10.8	6 **C** 12.0	7 **N** 14.0	8 **O** 16.0	9 **F** 19.0	10 **Ne** 20.1
11 **Na** 23.0	12 **Mg** 24.3											13 **Al** 27.0	14 **Si** 28.1	15 **P** 31.0	16 **S** 32.1	17 **Cl** 35.5	18 **Ar** 39.9
19 **K** 39.1	20 **Ca** 40.1	21 **Sc** 44.9	22 **Ti** 47.9	23 **V** 50.9	24 **Cr** 52.0	25 **Mn** 54.9	26 **Fe** 55.9	27 **Co** 58.9	28 **Ni** 58.7	29 **Cu** 63.6	30 **Zn** 65.4	31 **Ga** 69.7	32 **Ge** 72.6	33 **As** 74.9	34 **Se** 79.0	35 **Br** 79.9	36 **Kr** 83.8
37 **Rb** 85.5	38 **Sr** 87.6	39 **Y** 88.9	40 **Zr** 91.2	41 **Nb** 92.9	42 **Mo** 95.9	43 **Tc** 98.1	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 197.0	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 **Ac** (227)															

Lanthanides

58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.3	63 **Eu** 152.0	64 **Gd** 157.2	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0

Actinides

90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** 237.1	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (254)	100 **Fm** (257)	101 **Md** (258)	102 **No** (255)	103 **Lr** (256)

3. Physical constants

Avogadro's constant (N_A) = 6.02×10^{23} mol^{-1}

Charge on one electron = -1.60×10^{-19} C

Faraday constant (F) = 96 500 C mol^{-1}

Gas constant (R) = 8.31 J $K^{-1}mol^{-1}$

Ionic product for water (K_w) = 1.00×10^{-14} mol^2 L^{-2} at 298 K
(Self ionisation constant)

Molar volume (V_m) of an ideal gas at 273 K, 101.3 kPa (STP) = 22.4 L mol^{-1}
Molar volume (V_m) of an ideal gas at 298 K, 101.3 kPa (SLC) = 24.5 L mol^{-1}

Specific heat capacity (c) of water = 4.18 J g^{-1} K^{-1}
Density (d) of water at 25 °C = 1.00 g mL^{-1}

1 atm = 101.3 kPa = 760 mm Hg
0 °C = 273 K

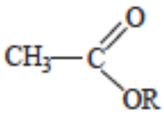
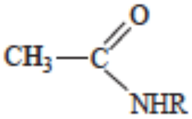
4. SI prefixes, their symbols and values

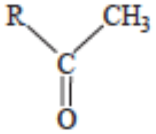
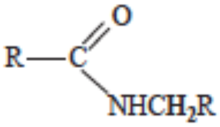
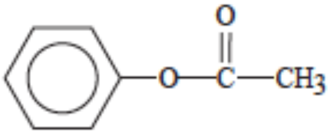
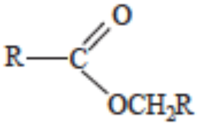
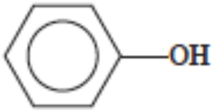
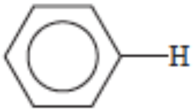
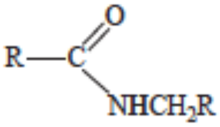
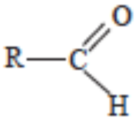
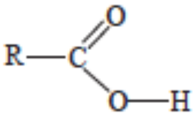
SI prefix	Symbol	Value
giga	G	10^9
mega	M	10^6
kilo	k	10^3
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

5. ^{1}H NMR data

Typical proton shift values relative to TMS = 0

These can differ slightly in different solvents. Where more than one proton environment is shown in the formula, the shift refers to the ones in bold letters.

Type of proton	Chemical shift (ppm)
R–CH_3	0.8–1.0
R–CH_2–R	1.2–1.4
RCH = CH–CH_3	1.6–1.9
R_3–CH	1.4–1.7
 or 	2.0

Type of proton	Chemical shift (ppm)
	2.1–2.7
$R-CH_2-X$ (X = F, Cl, Br or I)	3.0–4.5
$R-CH_2-OH$, $R_2-CH-OH$	3.3–4.5
	3.2
$R-O-CH_3$ or $R-O-CH_2R$	3.3
	2.3
	4.1
R–O–H	1–6 (varies considerably under different conditions)
$R-NH_2$	1–5
$RHC=CH_2$	4.6–6.0
	7.0
	7.3
	8.1
	9–10
	9–13

6. ^{13}C NMR data

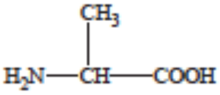
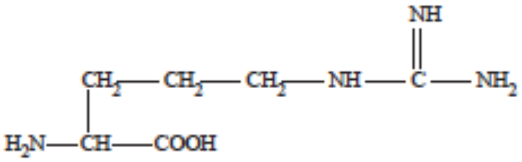
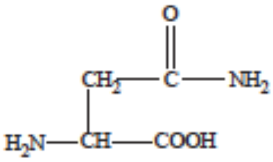
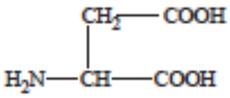
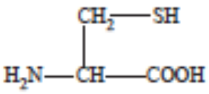
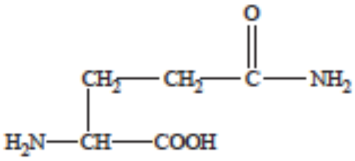
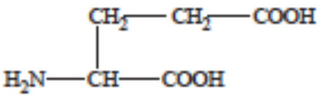
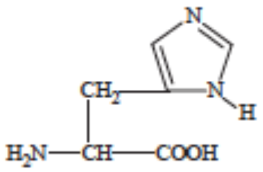
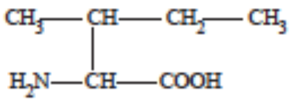
Type of carbon	Chemical shift (ppm)
$R{-}CH_3$	8–25
$R{-}CH_2{-}R$	20–45
$R_3{-}CH$	40–60
$R_4{-}C$	36–45
$R{-}CH_2{-}X$	15–80
$R_3C{-}NH_2$	35–70
$R{-}CH_2{-}OH$	50–90
$RC{\equiv}CR$	75–95
$R_2C{=}CR_2$	110–150
RCOOH	160–185

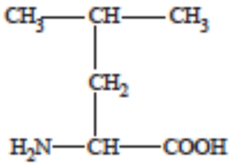
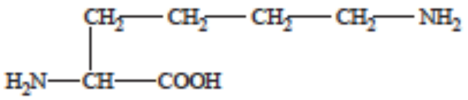
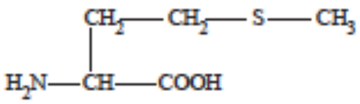
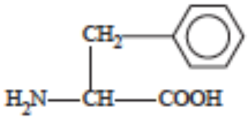
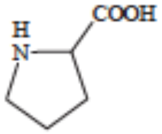
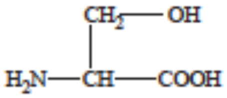
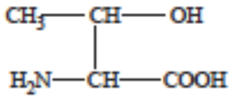
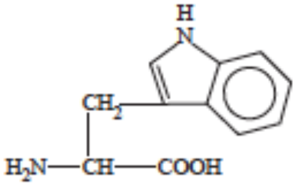
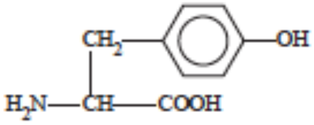
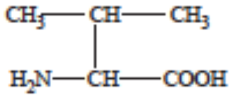
7. Infrared absorption data

Characteristic range for infrared absorption

Bond	Wave number (cm^{-1})
C–Cl	700–800
C–C	750–1100
C–O	1000–1300
C=C	1610–1680
C=O	1670–1750
O–H (acids)	2500–3300
C–H	2850–3300
O–H (alcohols)	3200–3550
N–H (primary amines)	3350–3500

8. 2-amino acids (*α*-amino acids)

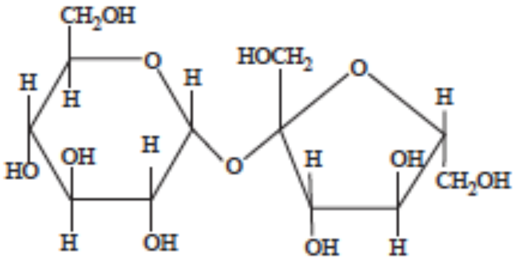
Name	Symbol	Structure
alanine	Ala	 $H_2N-\overset{\displaystyle CH_3}{\overset{\vert}{CH}}-COOH$
arginine	Arg	 $H_2N-\overset{\displaystyle CH_2-CH_2-CH_2-NH-\overset{\displaystyle NH}{\overset{\Vert}{C}}-NH_2}{\overset{\vert}{CH}}-COOH$
asparagine	Asn	 $H_2N-\overset{\displaystyle CH_2-\overset{\displaystyle O}{\overset{\Vert}{C}}-NH_2}{\overset{\vert}{CH}}-COOH$
aspartic acid	Asp	 $H_2N-\overset{\displaystyle CH_2-COOH}{\overset{\vert}{CH}}-COOH$
cysteine	Cys	 $H_2N-\overset{\displaystyle CH_2-SH}{\overset{\vert}{CH}}-COOH$
glutamine	Gln	 $H_2N-\overset{\displaystyle CH_2-CH_2-\overset{\displaystyle O}{\overset{\Vert}{C}}-NH_2}{\overset{\vert}{CH}}-COOH$
glutamic acid	Glu	 $H_2N-\overset{\displaystyle CH_2-CH_2-COOH}{\overset{\vert}{CH}}-COOH$
glycine	Gly	H_2N-CH_2-COOH
histidine	His	
isoleucine	Ile	 $H_2N-\overset{\displaystyle CH_3-CH-CH_2-CH_3}{\overset{\vert}{CH}}-COOH$

Name	Symbol	Structure
leucine	Leu	
lysine	Lys	
methionine	Met	
phenylalanine	Phe	
proline	Pro	
serine	Ser	
threonine	Thr	
tryptophan	Trp	
tyrosine	Tyr	
valine	Val	

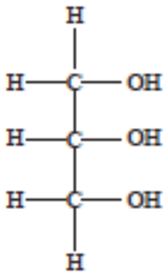
9. Formulas of some fatty acids

Name	Formula
Lauric	$C_{11}H_{23}COOH$
Myristic	$C_{13}H_{27}COOH$
Palmitic	$C_{15}H_{31}COOH$
Palmitoleic	$C_{15}H_{29}COOH$
Stearic	$C_{17}H_{35}COOH$
Oleic	$C_{17}H_{33}COOH$
Linoleic	$C_{17}H_{31}COOH$
Linolenic	$C_{17}H_{29}COOH$
Arachidic	$C_{19}H_{39}COOH$
Arachidonic	$C_{19}H_{31}COOH$

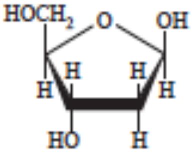
10. Structural formulas of some important biomolecules



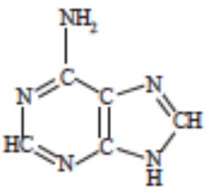
sucrose



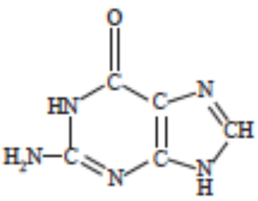
glycerol



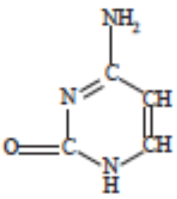
deoxyribose



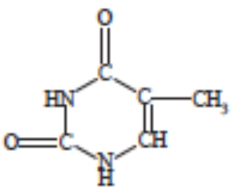
adenine



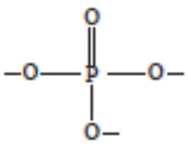
guanine



cytosine



thymine



phosphate

11. Acid-base indicators

Name	pH range	Colour change		K_a
		Acid	Base	
Thymol blue	1.2–2.8	red	yellow	2×10^{-2}
Methyl orange	3.1–4.4	red	yellow	2×10^{-4}
Bromophenol blue	3.0–4.6	yellow	blue	6×10^{-5}
Methyl red	4.2–6.3	red	yellow	8×10^{-6}
Bromothymol blue	6.0–7.6	yellow	blue	1×10^{-7}
Phenol red	6.8–8.4	yellow	red	1×10^{-8}
Phenolphthalein	8.3–10.0	colourless	red	5×10^{-10}

12. Acidity constants, K_a, of some weak acids at 25 °C

Name	Formula	K_a
Ammonium ion	NH_4^+	5.6×10^{-10}
Benzoic	C_6H_5COOH	6.4×10^{-5}
Boric	H_3BO_3	5.8×10^{-10}
Ethanoic	CH_3COOH	1.7×10^{-5}
Hydrocyanic	HCN	6.3×10^{-10}
Hydrofluoric	HF	7.6×10^{-4}
Hypobromous	$HOBr$	2.4×10^{-9}
Hypochlorous	$HOCl$	2.9×10^{-8}
Lactic	$HC_3H_5O_3$	1.4×10^{-4}
Methanoic	$HCOOH$	1.8×10^{-4}
Nitrous	HNO_2	7.2×10^{-4}
Propanoic	C_2H_5COOH	1.3×10^{-5}

13. Values of molar enthalpy of combustion of some common fuels at 298 K and 101.3 kPa

Substance	Formula	State	ΔH_c (kJ mol^{-1})
hydrogen	H_2	g	–286
carbon (graphite)	C	s	–394
methane	CH_4	g	–889
ethane	C_2H_6	g	–1557
propane	C_3H_8	g	–2217
butane	C_4H_{10}	g	–2874
pentane	C_5H_{12}	l	–3509
hexane	C_6H_{14}	l	–4158
octane	C_8H_{18}	l	–5464
ethene	C_2H_4	g	–1409
methanol	CH_3OH	l	–725
ethanol	C_2H_5OH	l	–1364
1-propanol	$CH_3CH_2CH_2OH$	l	–2016
2-propanol	$CH_3CHOHCH_3$	l	–2003
glucose	$C_6H_{12}O_6$	s	–2816

END OF DATA BOOK

CHEMOLOGY EDUCATION SERVICES

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CHEMISTRY Unit 3 & 4 Trial Exam
MULTIPLE CHOICE ANSWER SHEET

Colour the box after the letter corresponding to your answer.

1. A☐ B☐ C☐ D☐
2. A☐ B☐ C☐ D☐
3. A☐ B☐ C☐ D☐
4. A☐ B☐ C☐ D☐
5. A☐ B☐ C☐ D☐
6. A☐ B☐ C☐ D☐
7. A☐ B☐ C☐ D☐
8. A☐ B☐ C☐ D☐
9. A☐ B☐ C☐ D☐
10. A☐ B☐ C☐ D☐
11. A☐ B☐ C☐ D☐
12. A☐ B☐ C☐ D☐
13. A☐ B☐ C☐ D☐
14. A☐ B☐ C☐ D☐
15. A☐ B☐ C☐ D☐
16. A☐ B☐ C☐ D☐
17. A☐ B☐ C☐ D☐
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25. A☐ B☐ C☐ D☐
26. A☐ B☐ C☐ D☐
27. A☐ B☐ C☐ D☐
28. A☐ B☐ C☐ D☐
29. A☐ B☐ C☐ D☐
30. A☐ B☐ C☐ D☐

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SUGGESTED SOLUTIONS TO 2013 CHEMISTRY UNIT 3 & 4 TRIAL EXAM

Section A

1 C		**16 D**	
2 B		**17 A**	
3 D	n($PbCl_2$) = 0.595/278.2 = 0.00214mol = n(Pb^{2+}) [Pb^{2+}] = 0.00214/0.05) x 207.2 = 8.87g/L	**18 A**	
4 A	n(acetic acid) = 0.5 x 0.1= 0.05mol n(Na_2CO_3) = n(acetic acid)/2 = 0.05/2 = 0.025mol m(Na_2CO_3) = 0.025 x 106 = 2.65g	**19 B**	n(methanol) = 0.1/32 Energy from methanol = n x 715kJ = 2.23kJ Cal. Factor = Energy/ ΔT = 2.23/10 = 0.223 kJ
5 D		**20 B**	
6 D	C : H : O 12/12 : 2/1 : 16/16 1 : 2 : 1 Molar mass CH_2O = 30 Number of empirical formula units = 60/30 = 2 Molecular formula = $C_2H_4O_2$	**21 D**	Energy = m x C x ΔT $= \frac{10 \times 8.99 \times 10^{-1} \times 30}{1000}$ Heat capacity in Joules, divide by 1000 to change to kJ.
7 A		**22 C**	$2Br^- \rightarrow Br_2 + 2e$ occurs at the positive electrode. The anode.
8 B	$P_1V_1 / T_1 = P_2V_2 / T_2$ 4 x 80 / 300 = 4 x V_2/320 V_2 = 85.3L	**23 A**	T increases, K decreases if ΔH is negative. K decreases, reaction moves to left.
9 C		**24 A**	
10 B		**25 A**	Hydrogen used at double amount of CO due to ratio.
11 C	n(HCl) = 0.075 x 1= 0.075mol n(NaOH) = n(HCl) NaOH in excess 0.085 – 0.075 = 0.01M [OH-] = 0.01M [H^+] = 10^{-12}M pH = -log (10^{-12}) = 12	**26 C**	[SO_3] = 1.2/3 =0.4M [HF] = 0.3/3 = 0.1M [SF_6] = 1.5/3 = 0.5M $6.3 \times 10^{-3} = \frac{0.5M \times [H_2O]^3}{0.4 \times 0.1^6}$
12 A		**27 D**	

13 C		**28 C**	Metal must be stronger reductant than Fe. Metal is zinc EMF = E^0 (oxidant) - E^0 (reductant) = -0.44 – (-0.76) = 1.20V
14 C		**29 A**	Mn is the stronger oxidant. EMF = E^0 (oxidant) - E^0 (reductant) = -0.13 – (-1.19) = 1.06 V
15 A		**30 D**	Metal to be plated is negative. $Ag^+ + e \rightarrow Ag$ This is a reduction reaction which occurs at the cathode.

Section B ❶ = 1 mark

Question 1

(a) (i) (2-)methylpropan-2-ol;
the (H atoms in the three) $-CH_3$ groups are responsible for the peak at 1.3 ppm;
the $-$**OH** hydrogen atom is responsible for the peak at 2.0 ppm; ***[3]***
Accept explanations with suitable diagram.

(ii) (2-)methylpropan-1-ol;
the first peak (at 0.9 ppm) is due to the (H atoms in the) two $-CH_3$ groups (bonded to the second carbon atom) / $(\mathbf{CH_3})_2CHCH_2OH$;
the peak at 3.4 ppm is due to the (H atoms in the) $-CH_2-$ group / $(CH_3)_2CH\mathbf{H_2}OH$; ***[3]***
Accept explanations with suitable diagram.

(b) (i) butan-1-ol and butan-2-ol;

74: M^+ / $C_4H_{10}O^+$ / $CH_3CH_2CH_2CH_2OH^+$ **and** $CH_3CH_2CH(OH)CH_3{}^+$;

59: $C_3H_7O^+$ / $(M - CH_3)^+$ / $CH_2CH_2CH_2OH^+$ **and**
$CH_2CH(OH)CH_3{}^+$/$CH_3CH_2CH(OH)^+$;

45: $C_2H_5O^+$ / $(M - C_2H_5)^+$ / $CH_2CH_2OH^+$ **and** $CH(OH)CH_3{}^+$; ***[4]***
Accept explained answers instead of formulas.

(ii) butan-1-ol;
CH_2OH^+ / $(M - C_3H_7)^+$; ***[2]***
Penalize missing + signs once only in parts (b) (i) and (ii).

(c) they all contain O–H;
they all contain C–H;
they all contain C–O; ***[2 max]***
*Award **[1 max]** for same functional groups/bonds.*

Question 2

a) n(HCl) = 0.200M x 0.02720 = 5.44 x 10^{-3} mol ❶

b) n(HCl) excess = 0.100M x 0.02380ml = 2.38 x 10^{-3} mol ❶

c) n(HCl) reacted = 0.0054 – 0.00238 = 0.00306 mol ❶

d) $2\ HCl\ (aq) + CaCO_3\ (s) \rightarrow CaCl_2\ (aq) + CO_2\ (g) + H_2O\ (l)$ ❶❶

e) $n(CaCO_3) = n(HCl)/2 = 0.00306 / 2 = 0.00153$ mol ❶❶

f) $m(CaCO_3) = n \times M = 0.00153 \times 100 = 0.153$g ❶❶

$\%(CaCO_3) = (0.153/0.188) \times 100 = 81.4\%$ ❶

g) Only ($CaCO_3$) reacts with the acid. No other impurities that react with acid. ❶

Question 3

a) A: OH
B: C=O
C: C - O

Award [❶❶] for three correct, [❶] for two correct.

b) m/z 74: $C_2H_5COOH^+$
m/z 45: $COOH^+$
m/z 29 : $C_2H_5^+$; [❶❶❶]

Penalize missing + charge once only.

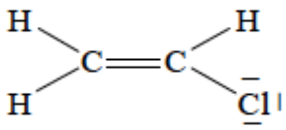
c) -COOH [❶]

d) CH_3CH_2COOH ❶

e) absorbs upfield/away from most other protons/H.s; low boiling point/bp / volatile / easily removed from sample; not toxic; highly unreactive (and hence does not interfere with sample) / inert; ❶

Question 4

(a) (i)

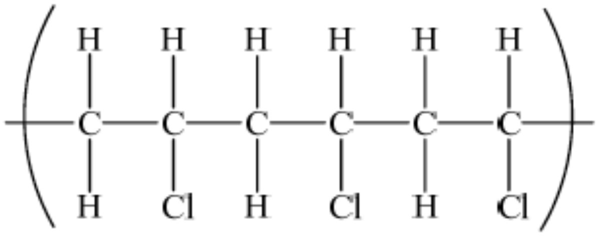


;

Accept lines, dots or crosses for electron pairs.
Lone pairs required on chlorine.

(approximately) 120°;
Accept any bond angle in the range $113-120^{o}$.

(ii)



;

Brackets not required for mark.
Allow correct condensed structural formula.
Continuation bonds from each carbon are required.
Cl atoms can be above or below carbon spine or alternating above and below.

(iii) plastics are cheap/versatile/a large industry / plastics have many uses / *OWTTE*; plastics are not biodegradeable / plastics take up large amounts of space in landfill / pollution caused by burning of plastics / *OWTTE*;
Do not accept plastics cause litter.
Allow plastics don't decompose quickly / OWTTE.

(b) (i) *Step 1:*
$CH_2CHCl + H_2 \rightarrow CH_3CH_2Cl$;

Step 2:
$CH_3CH_2Cl + OH^- \rightarrow CH_3CH_2OH + Cl^-$;
Allow NaOH or NaCl etc. instead of OH^- *and* Cl^-.
Allow abbreviated formulas C_2H_3Cl, C_2H_5Cl, C_2H_5OH.

c) i) $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ ❶❶

ii) No oxygen, warmth and yeast. ❶

d) H_2SO_4/H^+/acidified **and** $Cr_2O_7^{2-}$/(potassium/sodium) dichromate;

Accept suitable oxidizing agents (e.g. $KMnO_4$ etc.) but only with acid.

Ignore missing or incorrect oxidation states in reagents.

❶❶

e) $CH_3COOH\,(aq) + H_2O\,(l) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$

OR

$CH_3COOH\,(l) + H_2O\,(l) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$

OR

$CH_3COOH\,(aq) \rightleftharpoons CH_3COO^-(aq) + H^+(aq)$

correct equation;

state symbols **and** $\rightleftharpoons$;

BL acid is CH_3COOH and cb is CH_3COO^- / BL acid is H_3O^+ and cb is H_2O;

❶❶❶❶

Question 5

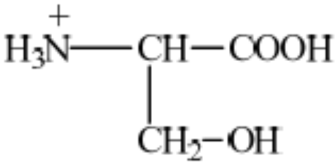
a) there may have been contaminant is the water sample used to make the standard solutions. ❶

b) The wavelength of the sodium lamp will only be absorbed by electrons of sodium atoms thus promoting them to higher levels. ❶ The wavelength of light produced by the sodium lamp will not cause calcium atoms to absorb this energy. ❶

c) Reading from graph concentration is 340g/L. Dilution Factor 500/25 = 20 ❶
Concentration of sauce = 340 x 20 = 6800 g/L ❶

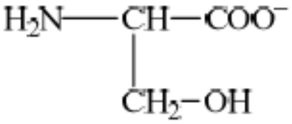
Question 6

(a) (i)



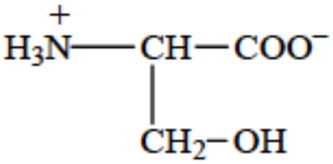
$\overset{+}{H_3N}-\underset{\displaystyle CH_2-OH}{CH}-COOH$;

(ii)



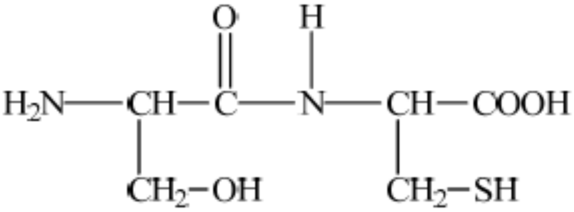
$H_2N-\underset{\displaystyle CH_2-OH}{CH}-COO^-$

(b)

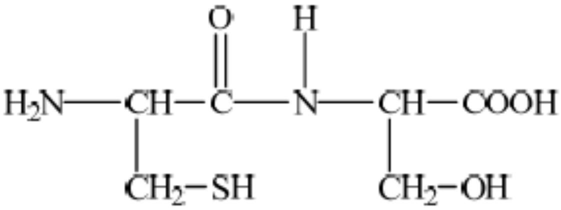


$\overset{+}{H_3N}-\underset{\displaystyle CH_2-OH}{CH}-COO^-$

(c)



$H_2N-\underset{\displaystyle CH_2-OH}{CH}-\overset{\displaystyle O}{\overset{\|}{C}}-\overset{\displaystyle H}{\overset{|}{N}}-\underset{\displaystyle CH_2-SH}{CH}-COOH$



$H_2N-\underset{\displaystyle CH_2-SH}{CH}-\overset{\displaystyle O}{\overset{\|}{C}}-\overset{\displaystyle H}{\overset{|}{N}}-\underset{\displaystyle CH_2-OH}{CH}-COOH$

(d) van der Waals attraction between non polar groups;
ionic bonding between charged groups/NH_3^+ and COO^-;
hydrogen bonding between H bonded to O or N with another O or N;
disulfide bridges/bonds between two S atoms (in cysteine);
peptide linkages/bonds between $-COOH$ and $-NH_2$ groups; ***[5]***
*If no examples given, award **[2 max]** for 4 or 5 interactions and **[1 max]** for 2 or 3 interactions.*

e) i) A : hydrogen bonds ❶
B: Disulfide link ❶

ii) B is stronger, covalent bond. ❶

iii) The pH can disrupt the hydrogen bonds the affect the 3D shape. This will make the enzyme deactivate. ❶❶

Question 7

a) Energy = m x C x ΔT

= 100 x 4.18 x 35

= 14.63 kJ ❶❶

b) n(ethanol) = 1.78/46 = 0.0387 mol❶

Energy/mol = 14.63/ 0.0387

= 378 kJ/mol ❶

c) Heat loss on burning ethanol. ❶ Incomplete combustion of ethanol ❶

Question 8

a) $C_6H_{12}O_6$ + $6O_6$ → $6CO_2$ + 6 H_2O ❶❶

b) 2997 – 181 = 2816 kJ mol^{-1} ❶

ΔH = -2816 kJ mol^{-1} Reaction is exothermic❶

Question 9

a) $AgNO_3$ (aq) + NaCl (aq) → AgCl (s) + $NaNO_3$ (aq) ❶

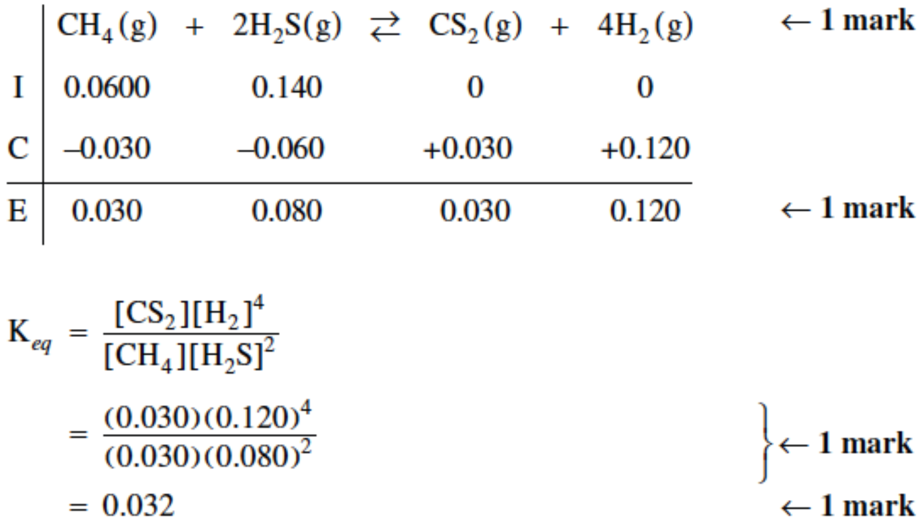
b) n(AgCl) = 1.57/143.4 = 0.0109 mol ❶❶

c) n(Ag) = n(AgCl) ❶

m(Ag) = 0.0109 x 107.9 = 1.18g ❶

%Ag = [1.18/1.56] x 100 = **75.6%** ❶

Question 10



	$CH_4(g)$	+	$2H_2S(g)$	⇌	$CS_2(g)$	+	$4H_2(g)$	← **1 mark**
I	0.0600		0.140		0		0	
C	–0.030		–0.060		+0.030		+0.120	
E	0.030		0.080		0.030		0.120	← **1 mark**

$$K_{eq} = \frac{[CS_2][H_2]^4}{[CH_4][H_2S]^2}$$

$$= \frac{(0.030)(0.120)^4}{(0.030)(0.080)^2} \quad \}\leftarrow \textbf{1 mark}$$

$$= 0.032 \quad \leftarrow \textbf{1 mark}$$

Question 11

$$\begin{array}{l|lcccccl}
 & H_2X & + & H_2O(\ell) & \rightleftarrows & H_3O^+ & + & HX^- & \leftarrow \textbf{1 mark} \\
\text{[I]} & 2.00\,M & & & & 0 & & 0 & \\
\text{[C]} & -0.25 & & & & +0.25 & & +0.25 & \\
\hline
\text{[E]} & 1.75 & & & & 0.25 & & 0.25 & \leftarrow \textbf{1 mark}
\end{array}$$

$$\mathrm{pH} = 0.60; \left[H_3O^+\right] = 0.25\ M \qquad \leftarrow \textbf{1 mark}$$

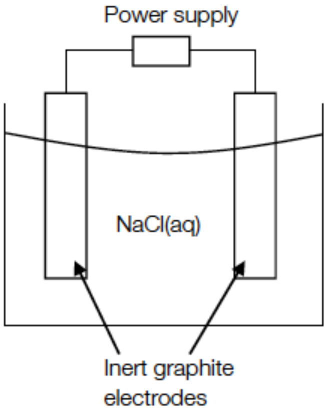
$$K_a = \frac{[H_3O^+][HX^-]}{[H_2X]}$$

$$= \frac{(0.25)(0.25)}{1.75} \qquad \leftarrow \textbf{1 mark}$$

$$= 0.036 \qquad \leftarrow \textbf{1 mark}$$

Question 12

a)



b) At low concentrations of NaCl, water is preferentially oxidised and reduced.

<u>Positive electrode (anode):</u> $H_2O(l) \rightarrow O_2\,(g) + 2H^+\,(aq) + 2e^-$ ❶

Bubbles are observed because oxygen gas is produced. The litmus paper is red because hydrogen ions are produced (acidic environment). ❶

Negative electrode (cathode):
$H_2O(l) \rightarrow H_2\,(g) + OH^-\,(aq)$ ❶
Bubbles are observed because hydrogen gas is formed. The litmus paper is blue because hydroxide ions are produced (basic environment). ❶

c) An electrolytic cell requires a power source to operate and converts electrical energy into chemical energy. ❶ A galvanic cell operates spontaneously and converts chemical energy into electrical energy. ❶

Question 13

a) Anode $H_2 (g) + 2OH^- (aq) \rightarrow 2H_2O (l) + 2e$ ❶

Cathode $O_2 (g) + 2H_2O (l) + 4e \rightarrow 4OH^- (aq)$ ❶

b) i) Conduct electricity / catalyst/ allow gases to mix / site of oxidation and reduction ❶❶

ii) Any two of:

- Fuel cells are highly efficient in converting chemical energy directly to electrical energy (about 60%). Petrol engines are much less about 25 – 30%
- The product of cell is water. Preferable to polluatnts from petrl engines.
- The reactants, hydrogen and oxygen, can be produced from water and so are renewable sources, unlike petrol ❶❶

c) $n(e) = \frac{7.82 \times 2.00 \times 60 \times 60}{96500} = 0.583$ mol ❶ ❶

$n(H_2) = ½\ n(e) = 0.292$ mol ❶

$v(H_2) = \frac{0.292 \times 8.31 \times 473}{3000}$❶

$= 0.382$ L or 382 ml ❶