NAME: _____

VCE CHEMISTRY

Practice Written Examination

Reading time: 15 minutes

Writing time: 2 hours 30 minutes

QUESTION AND ANSWER BOOKLET

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	30		30
B	11		100
		Total	130

- Students are permitted to bring into the examination room: blue or black pens, pencils, highlighters, erasers, sharpeners and ruler. A scientific calculator is allowed.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied

- Question and answer book of 32 pages.
- A Data Book.
- Answer sheet for multiple choice questions.

Instructions

- Write your **student name** in the space provided above on this page.
- Check that your **name** is printed on your answer sheet for multiple-choice questions.
- 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.
- You may keep the data book.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

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

Identify which of the following 1M acid solutions has the least number of conjugate ions present.

A. HF

B. HCl

C. HNO_2

D. HCN

Question 2

Ethanoic acid (CH_3COOH) is a weak acid. Hydrochloric acid (HCl) and sulfuric acid (H_2SO_4) are strong acids.

10.00mL solutions of 0.10M concentration of each of the three acids were separately titrated with a 0.10M solution of sodium hydroxide (NaOH)

To react completely

A. the same amount of NaOH would be used for all three acids
B. more NaOH would be needed for HCl than CH_3COOH but less than H_2SO_4
C. the same amount of NaOH would be used for HCl and H_2SO_4 but less would be needed for CH_3COOH
D. the same amount of NaOH would be needed for HCl and CH_3COOH but H_2SO_4 would require more.

Question 3

Which of the following contain empirical formulae only?

A. CH_4, C_2H_6, $C_6H_5CH_3$, CH_3COOH
B. HNO_3, $Fe_2(SO_4)_3$, $C_6H_5CH_3$, CH_3Cl
C. CH_3OH, C_2H_6O, $CuSO_4.5H_2O$, $C_6H_{12}O_6$
D. C_4H_8, CCl_4, $Mg(OH)_2$, $K_2Cr_2O_7$

Question 4

Which one of the following fertilisers has the least percentage by mass of nitrogen (N)?

- **A.** Ammonium sulphate
- **B.** Ammonium nitrate
- **C.** Ammonium phosphate
- **D.** Urea $(NH_2)_2CO$

Question 5

A sample of chlorine (M_r = 71.0) has a mass of 21.1g and occupies a volume of 9 L.

Which of the following values can be determined for the sample of chlorine?

I amount

II %w/v

III density

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

Question 6

Ethane gas undergoes complete combustion is according to the following equation

$2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2)(l)$ $\Delta H = -3120 kJ\ mol^{-1}$

Which of the following quantities of ethane will release 637kJ of energy?

- **A.** 3.00 mol
- **B.** 100 g
- **C.** 10.0L at SLC
- **D.** 2.408×10^{23} atoms

Question 7

A number of analytical techniques can be used to measure the concentration of sodium chloride in seawater.

Which of the following methods cannot be used?

I gravimetric analysis

II flame tests

III atomic absorption spectroscopy

IV High Performance Liquid Chromatography.

A. I and II
B. II and III
C. III and IV
D. II and IV

Question 8

The salt content of a sample of chicken noodle soup was determined using gravimetric analysis. A precipitate of silver chloride was produced, dried and weighed.

Systematic errors that may occur in this analysis include:

I some precipitate remained in the reaction flask after the filtration process

II the precipitate was not dried and weighed until a constant mass was obtained

III the precipitate was not rinsed with deionised water before it was weighed

IV the precipitate was rinsed with excess deionised water.

Which of these errors would cause an overestimate in the mass of silver chloride present in the sample?

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

Question 9

When a lead acid battery is recharging

- **A.** the concentration of sulphuric acid electrolyte is decreasing
- **B.** the pH of the electrolyte is increasing
- **C.** the pH of the electrolyte is decreasing
- **D.** the concentration of the sulphuric acid is the same concentration as when discharging.

Question 10

The addition of a catalyst to a chemical reaction

- **A.** lowers the value of the enthalpy change for the forward reaction only
- **B.** lowers the value of the enthalpy for the forward reaction only
- **C.** lowers the chemical energy of the reactants
- **D.** lowers the activation energy required for the reaction to occur.

Question 11

The volume of 2.00 M HCl that must be diluted to make 200mL of 0.010M HCl is

- **A.** 0.10L
- **B.** 10.0mL
- **C.** 10.0 μL
- **D.** 1.00 mL

Question 12

A student carried out a titration to determine the exact concentration of HCl using a standard solution of sodium carbonate. Using a pipette, a 20.00 mL aliquot of sodium carbonate was transferred to a 250mL conical flask. Prior to using the pipette, each time prior to obtaining an aliquot of sodium carbonate the final rinsing was with distilled water.

This would result in the student's calculation of the concentration of the HCl

- **A.** underestimated
- **B.** overestimated
- **C.** have no effect on the estimated HCl concentration
- **D.** with repeated trials, reduce the systematic errors, minimising the effect on the result.

Question 13

The concentration of Na^+ ions in 100 mL of 0.0500 M Na_2CO_3 solution, in g L^{-1} is

- **A.** 1.15
- **B.** 0.115
- **C.** 2.30
- **D.** 0.230

Question 14

Zinc can be produced industrially by a redox reaction using carbon monoxide.

$CO(g) + ZnO(s) \rightarrow Zn(l) + CO_2(g)$

During this reaction the oxidation number of zinc changes from

A. +2 to 0, and CO is the reductant
B. +2 to 0, and CO is the oxidant
C. 0 to +2, and CO is the reductant
D. 0 to +2, and CO is the oxidant.

Question 15

Iron can be readily oxidised in the presence of copper ions. The chemical equation is

$$Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + \_\_\_\_\_$$

To complete this redox reaction, the missing chemical substance is

A. $Cu^{+}(aq)$
B. Cu (s)
C. $Cu^{4+}(aq)$
D. $Cu^{3+}(aq)$

Question 16

When a pale green solution containing Fe^{2+} ions is mixed with a purple coloured acidified solution of MnO_4^- ions, the purple colour disappears. The unbalance equation for the reaction is:

$$\_\_\_\_\_MnO_4^-(aq) + \_\_\_H^+(aq) + \_\_\_\_ Fe^{2+}(aq) \rightarrow \_\_\_Mn^{2+}(aq) + \_\_\_Fe^{3+}(aq) + \_\_\_H_2O(l)$$

When correctly balanced, the number of mole of Fe^{2+} ions reacting with 1 mole of MnO_4^- and the number of mole of Fe^{3+} ions produced is

A. 1 mole Fe^{2+} and 1 mole Fe^{3+}
B. 3 mole Fe^{2+} and 2 mole Fe^{3+}
C. 5 mole Fe^{2+} and 3 mole Fe^{3+}
D. 5 mole Fe^{2+} and 5 mole Fe^{3+}

Question 17

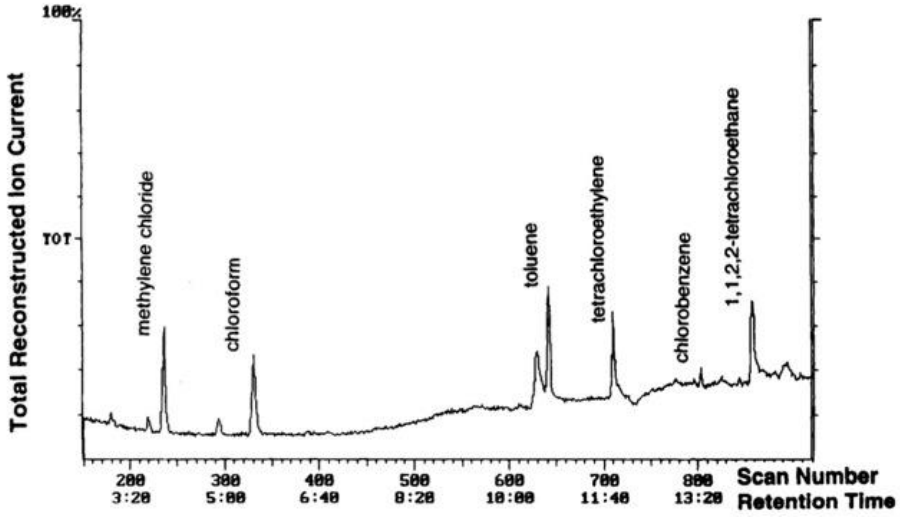
Paper chromatography was used to separate two components from a dye. One component, A, ($R_f = 0.50$) moved a distance of 2.0cm from the origin, whilst another component, B moved 1.0 cm further than component A.

The R_f value of component B is closest to

A. 0.33
B. 0.60
C. 0.75
D. 0.25

Question 18

Gas chromatography can be used in the detection of organic volatile substances. The diagram below shows the gas chromatograph of an air sample taken from a synthetic organic chemistry laboratory. (Chai and Pawliszyn 1995).



http://faculty.virginia.edu/analyticalchemistry/GC%20VOC%20Final/GC%20&%20VOC%203.html

The following statements refer to this diagram.

I The boiling points of the compounds arranged from lowest to highest are methylene chloride, chloroform, toluene, tetrachloroethylene, chlorobenzene, 1,1,2,2-tetrachloroethane.

II Nitrogen could have been used as a carrier gas for the mobile phase.

III The retention times will stay the same if the temperature at which the chromatography is run is increased.

Which of the above statements is true?

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

Question 19

When Nuclear Magnetic resonance spectroscopy is used to identify an organic substance

A. the bonds that contain hydrogen atoms vibrate and stretch or bend in the induced magnetic field
B. the bonds in the molecule will stretch and bend at characteristic frequencies
C. the molecule will absorb radiation of a known wavelength, exciting electrons
D. the hydrogen nuclei align themselves in the induced magnetic field.

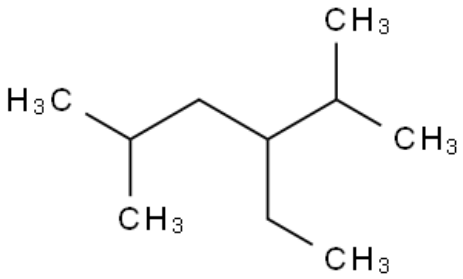
Question 20

The concentration and identification of 1,2-ethandiol would best be analysed by

A. gas-liquid chromatography
B. a combination of gas chromatography and mass spectrometry
C. a combination of high performance liquid chromatography and mass spectrometry
D. acid/base titration.

Question 21

What is the correct systematic naming for the following compound?



A. 2,5-methyl-3-ethylpentane
B. 2,5-dimethyl-4-ethylpentane
C. 3-ethyl-2,5-dimethlyhexane
D. 3-ethyl -5,5-dimethlypentane.

Question 22

The number of structural isomers of C_5H_{10}, each containing a double bond is

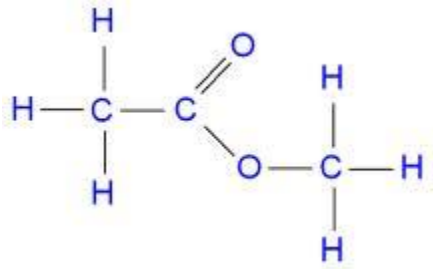
A. 6
B. 5
C. 4
D. 3

Question 23

Which one of the following compounds will react with dilute sodium hydroxide and dilute nitric acid?

A. C_4H_9Br
B. $HOOCHCH_2CH_2COOH$
C. $C_3H_7NH_2$
D. $H_2NC_3H_6COOH$

Questions 24 and 25 refer to the following diagram.



Question 24

The systematic name for this molecule is

A. Ethyl methanoate
B. Methyl- ethanoic acid
C. Methyl ethanoate
D. Ethyl-butanoic acid

Question 25

The molecule shown can be prepared from

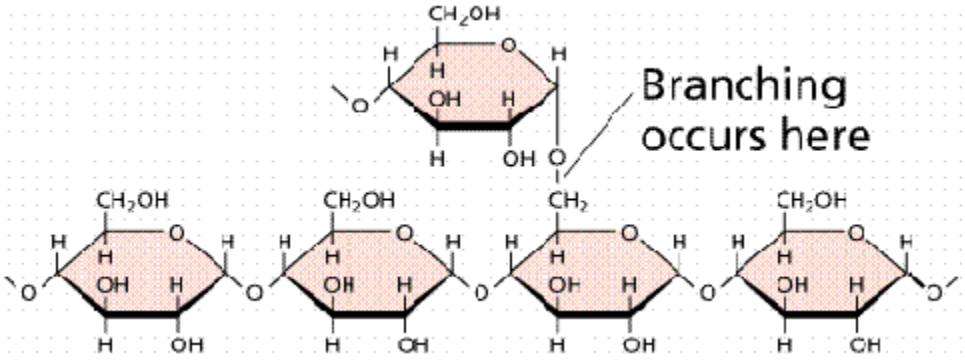
A. methanol, ethanol, sulphuric acid and acidified dichromate
B. methanoic acid, ethanol , sulphuric acid, water and a catalyst
C. methanol, ethanoic acid, sulphuric acid and water
D. methanoic acid, ethanol, sulphuric acid and acidified dichromate.

Question 26

The order that correctly represents the **increasing** value for the heat of combustion per g of fuel is

A. hydrogen, methane, methanol, ethene
B. ethene, methanol, methane, hydrogen
C. methane, methanol, hydrogen, ethene
D. methanol, ethene, methane, hydrogen.

Question 27



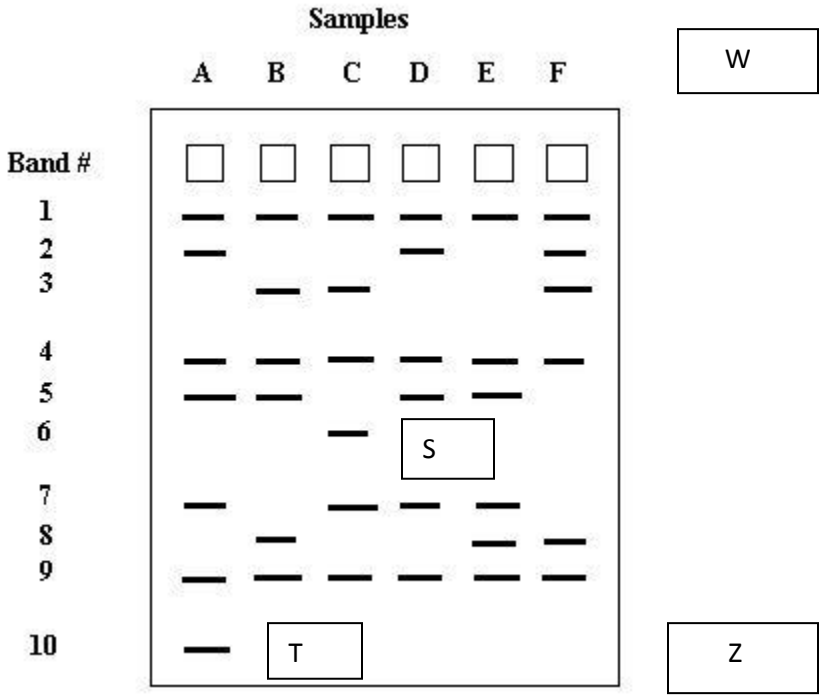
http://www.fas.org/irp/imint/docs/rst/Sect20/A12.html

Hydrolysis of the above involves the following

A. the formation of the monomer glucose plus water
B. the formation of the monomer glucose plus hydrogen
C. the formation of the monomer glucose
D. the formation of the monomer glucose plus carbon dioxide.

Question 28

Gel Electrophoresis is a processes used to analyse DNA. Fragments of DNA can be separated by allowing the DNA to run through an agarose gel under a process that requires an electric current. Samples of DNA will be loaded into the wells from A to F.



http://biology.arizona.edu/sciconn/lessons2/alongi/Lesson5_3.htm

From the gel electrophoresis

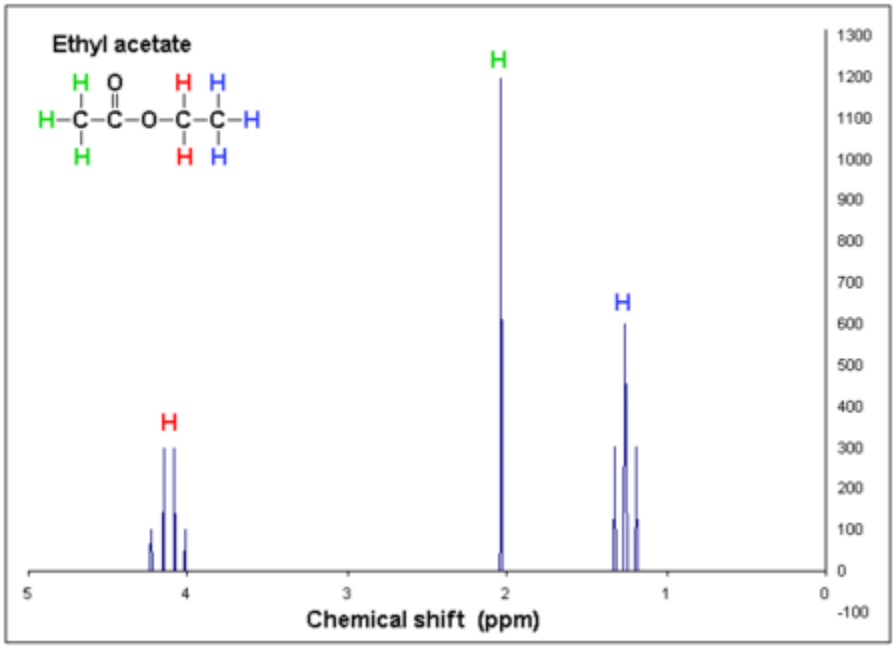
A. the negative terminal is connected at W and the fragment S has a lower molecular mass than the fragment T
B. the negative terminal is connected at Z and the fragment T has a lower molecular mass than fragment S
C. the positive terminal is at W and fragment T moves at a faster rate through the gel than fragment S
D. the positive terminal is at Z and fragment S moves through the gel at a slower rate than fragment T.

Question 29

Which one of the following amino acids would be the least soluble in an aqueous solution at pH 7?

A. Threonine
B. Valine
C. Leucine
D. Cysteine

Question 30



http://en.wikipedia.org/wiki/Proton_NMR

For the ^{1}H NMR of ethyl ethanoate (ethyl acetate) above

A. the chemical shift at 1.2 is due to the hydrogen's of CH_3COO^- and is a triplet
B. the chemical shift at 2.1 is due to the hydrogen's of CH_3COO^- and is a singlet
C. the chemical shift at 4.2 is due to the hydrogen's of CH_3COO^- and is a quartet
D. the chemical shit at 1.2 is due the hydrogens of $CH_3CH_2^-$ and is a septet.

SECTION B

Instructions for Section B
Answer **all** questions in the spaces provided. Write using a 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 answer 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 formulas for individual substances include an indication of state; for example, $H_2(g)$; NaCl(s)

Question 1 (5 marks)

a. Describe standard conditions at which the electrochemical series was constructed. 3 marks

_____

_____

_____

b. What is the pH of the reference half-cell solution under standard conditions? 2 marks

_____

_____

_____

_____

Question 2 (3 marks)

a. In the self-decomposition of hydrogen peroxide, hydrogen peroxide can act both as a reductant and an oxidant. Write the half equation when hydrogen peroxide is acting as an oxidant. Include all states and the E° value. 1 mark

_____

b. At standard conditions, give the cell potential difference for the self-decomposition of hydrogen peroxide. 1 mark

_____

_____

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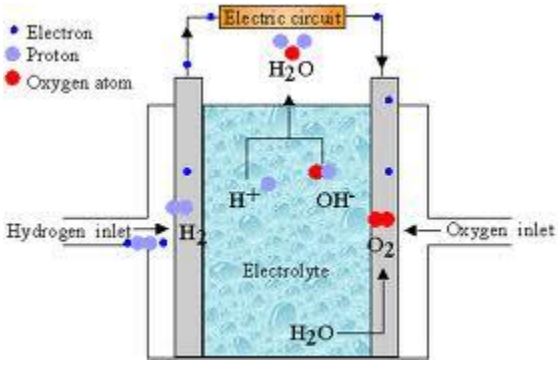
c. Explain why the self-decomposition of hydrogen peroxide is predicted to occur yet hydrogen peroxide can be stored at room temperature for years and not decompose. 1 mark

_____

_____

Question 3 (7 marks)

Alkaline fuel cells



http://www.cheng.cam.ac.uk/research/groups/electrochem/JAVA/electrochemistry/ELEC/l10html/main.html

a. Circle the term that best describes this type of cell.

Galvanic Electrolytic 1 mark

b. Write the equation for the reaction occurring at the cathode of an alkaline fuel cell. 1 mark

_____

c. Write the reaction occurring at the anode. 1 mark

_____

d. A commercially produced alkaline fuel cell has electrodes that are highly porous.
Explain the reason for porous electrodes. 1 mark

_____

_____

e. Explain one main difference between a fuel cell and a primary cell. 1 mark

_____

_____

f. Methanol fuel cells are another type of fuel cell that uses methanol as a reactant fuel. Give one advantage of using a fuel cell constructed to use methanol. 1 mark

_____

_____

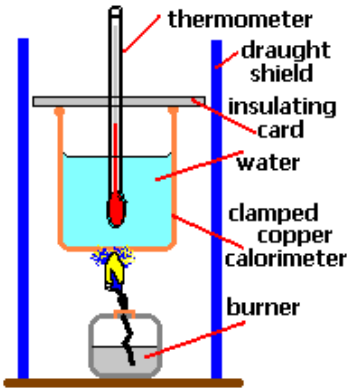
g. Give one disadvantage of using methanol in a fuel cell. 1 mark

_____

_____

Question 4 (20 marks)

An experiment was set up to determine experimentally, the molar enthalpy of methanol, ethanol and propan-1-ol. The apparatus used is shown in the diagram below. The volume of water used was 100.0ml.



http://www.docbrown.info/page07/delta1Hc.htm

The experimental results obtained are recorded in the following table:

Measurement	Methanol	Ethanol	Propan-1-ol
Initial mass of spirit burner plus alkanol(g)	155.63	157.85	154.83
Final mass of spirit burner plus alkanol(g)	151.74	154.33	152.16
Mass of alkanol burnt(g)	1.59	1.82	1.37
Initial temperature of water (°C)	21.3	21.5	21.5
Final temperature of water (°C)	79.5	78.2	77.0

a. Calculate the energy(J) released for each of the fuels. 3 marks

Methanol	Ethanol	Propanol

b. Determine the amount (n) of each fuel and the heat of combustion ($kJmol^{-1}$) for each fuel. 6 marks

Methanol	Ethanol	Propanol

c. Complete the table below. Compare the molar enthalpy of combustion for each of the three fuels with that of the experimental data calculated. 3 marks

Alkanol	Experimental data	ΔHc ($kJmol^{-1}$)
Methanol		
Ethanol		
Propan-1-ol		

_____

_____

_____

_____

_____

d. Write the complete thermochemical equation for the combustion of propanol. 2 marks

_____

_____

e. When comparing the heat of combustion to the theoretical values, there is consistently a significant difference. Identify **2** sources of error that would have contributed to this difference in values.
2 marks

_____

_____

_____

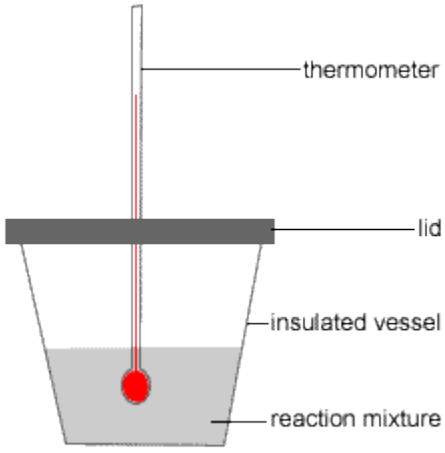
_____

f. To make results more reliable and reduce extraneous variable identify one important improvement of the experimental design to ensure validity. 1 mark

_____

_____

In another experiment the dissolution of ammonium chloride in water was determined using a polystyrene cup, a cover for the cup and a thermometer. The initial temperature was 21.5℃ and the final temperature was 18.7℃.



http://www.ausetute.com.au/heatreact.html

g. Write a complete thermochemical equation for the dissolution of ammonium chloride in water, including whether Δ H would be positive or negative. 2 marks

_____

_____

h. What is one assumption made for the aqueous solution of ammonium chloride when calculating the energy value (J)? 1 mark

_____

_____

Question 5 (6 marks)

Students were provided with ionisation constant of water in their Data Book.

From this three students were discussing exactly what a neutral solution was**.**

Nicholas said that it was a solution with a pH = 7; David said that is was when $[H_3O^+] = [OH^-]$ but thought the pH did equal 7. Jack said that Nicholas and David were both saying the same thing and were both correct.

Comment on the views expressed by each of the three students, giving an explanation for each view.

Question 6 (11 marks)

A back titration was used to determine the percentage composition of magnesium hydroxide found in antacid tablets.

The procedure involved crushing and weighing two antacid tablets (3.40g). This was placed in a 250.0mL conical flask.

25.6 ml of 3.30M HCl was added to the flask.

a. Write the equation for the reaction, including states. 1 mark

_____

The excess HCl was titrated with 0.0740M NaOH, according to the equation:

$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

b. What would be the most suitable indicator to use to determine the endpoint of this reaction? 1 mark

_____

The average titre was 27.4mL

c. Calculate the number of moles of HCl added to the antacid tablet solution. 1 mark

_____

_____

_____

d. Calculate the number of moles of HCl that reacted with the sodium hydroxide. 1 mark

_____

_____

_____

e. Determine the number of moles of HCl which reacted with the crushed antacid tablets, to the correct number of significant figures. 1 mark

f. Determine the %(m/m) of magnesium hydroxide present in an antacid tablet. 3 marks

g. A bubble was present below the tap of the burette. During the titration the bubble was expelled from the burette. Explain how this error would have affected the concentration of magnesium hydroxide calculated from this experiment. 2 marks

h. Why was it necessary to perform a back titration to determine the concentration of magnesium hydroxide present in antacid tablets? 1 mark

Question 7 (10 marks)

The gases N_20_4 and NO_2 were sealed in a 5.00 litre vessel and allowed to reach equilibrium at 298 K. The equation for the reaction is

$N_2O_4(g) \leftrightarrows 2NO_2(g)$ $\Delta H = +57$ kJ mol^{-1}

Colourless Brown

The value of K at 298 K = 0.0510 M

a. Write an expression for the equilibrium law for this reaction. 1 mark

_____

_____

b. Calculate the mass (g) of NO_2 present in the 5.00 L vessel at equilibrium at 298K containing 10.0g of N_2O_4. Provide the correct number of significant figures in you final answer. 6 marks

c. When the above mixture was heated to 373 K and maintained at this temperature, describe and explain, using Le Chatelier's principle, what would be observed. 3 marks

Question 8 (10 marks)

Sulphur dioxide and nitrogen dioxide were admitted to an empty vessel which was then sealed and the system was allowed to reach equilibrium at temperature X℃, and time, *t* secs.

$NO_2(g) + SO_2(g) \leftrightarrow NO(g) + SO_3(g)$

a. Use the axes below to sketch a graph of the **rates** of the forward and back reactions against time, starting at t = 0 and continue the graph to indicate when equilibrium (t_1) was established and also the rate after equilibrium has been established.
Label the axis, the forward and reverse reactions and indicate where equilibrium is established.
4 marks

b. On the same axis, sketch a graph of the rates for the forward and back reactions for the same reaction when a **catalyst** has also been added to the mixture at t = 0 seconds. Temperature is kept constant. Indicate the time,t2 where equilibrium is established with a catalyst. 2 marks

c. Describe how a catalyst alters the rate and position of equilibrium for this reaction. 2 marks

_____

_____

_____

d. Use the collision theory to explain how an increase in temperature could be used to increase the rate of this reaction. 2 marks

_____

_____

_____

_____

Question 9 (10 marks)

Water pollution can result from lead. The concentration of lead ions (Pb^{2+}) in a sample of water can be determined by the addition of an aqueous solution of 0.200M sodium sulphate (Na_2SO_4) to exactly 250.00 mL of this water to form a precipitate.

a. Write an ionic equation for the reaction. 1 mark

_____

b. The filtered precipitate was rinsed with deionised water. It was dried in an oven at 96℃. Over 5 days the following weighings were recorded.

Sample of Lead precipitate	Mass (g)
1	0.4732
2	0.4616
3	0.4612
4	0.4613
5	0.4620

Calculate the mass (g) of lead in the precipitate. 3 marks

c. Calculate the molarity of Pb^{2+} ions in the polluted water sample. 1 mark

d. The maximum accepted level of Pb^{2+} in safe drinking water is 0.015 ppm. Compare the level of Pb^{2+} in this polluted water (mg/L) to the acceptable standard. 1 mark

_____

_____

_____

_____

_____

e. The procedure assumes that there were no other ions in the polluted water, such as arsenic or mercury that would form a precipitate. If there had been, how would this have affected the resulting concentration of Pb^{2+} obtained? 1 mark

_____

_____

f. Calculate the minimum volume (mL) of aqueous 0.200M sodium sulphate that needed to be added to the 250ml of polluted water to precipitate all the lead ions. 2 marks

_____

_____

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_____

g. Why was 15 mL used? 1 mark

_____

_____

Question 10 (12 marks)

Atomic absorption spectroscopy (AAS) was used to investigate the concentration of calcium in a variety of milk samples. The spectrophotometer has a special light source, an aspirator-burner, a monochromators and a detector.

a. What feature must the lamp used in the analysis of calcium have? 1 mark

_____

_____

b. Explain the function of the aspirator-burner. 2 marks

_____

_____

_____

_____

An experiment was carried out to determine the percentage of calcium in a particular sample of milk using AAS. The AAS was first calibrated with solutions of known calcium concentrations before the unknown samples were investigated.

1.00ml of the milk sample was pipetted into a 100ml volumetric flask. 50ml of 2000 mgL^{-1} La^{2+} solution was added to displace the Ca^{2+} from its bound form to the free Ca^{2+} ion. This was then filtered and 2ml of the filtrate was transferred to a 10ml conical flask, a further 5ml of the La^{2+} solution added and made up to 10mL with distilled water, ready for analysis using a spectrophotometer. The following results were obtained.

	Calcium concentration(mgL^{-1})	**Absorbance reading**
Blank solution	0.0	0.007
Calcium standard 1	2.5	0.197
Calcium standard 2	5.0	0.404
Calcium standard 3	7.5	0.560
Calcium standard 4	10.0	0.721
Sample		0.293

c. Plot a graph of concentration versus absorbance on the graph below. 3 marks

d. From the graph, what is the concentration, mgL^{-1} of the total dissolved Ca^{2+} (aq) in the diluted milk sample? 1 mark

_____

e. What is the total dissolved calcium, (mgL^{-1}) in the milk sample? 2 marks

_____

_____

_____

_____

f. Calculate the percentage, (m/v) of calcium in the milk sample. 1 mark

_____

_____

_____

g. Give a reason for the blank solution recording an absorbance reading of 0.007. 1 mark

_____

_____

_____

h. The milk sample also contained sodium ions. Explain why these ions do not interfere with the absorbance of the wavelength of radiation selected for calcium. 1 mark

_____

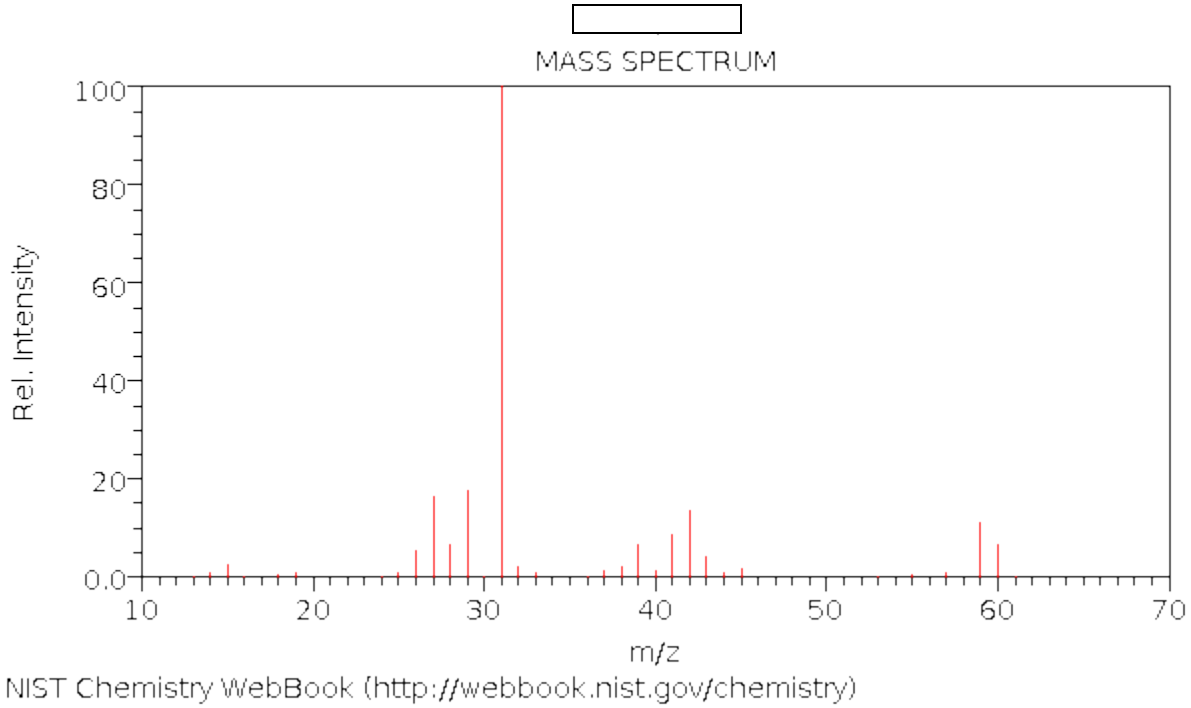
_____

_____

_____

Question 11 (6 marks)

The following is the mass spectrum of an organic molecule, an alkanol containing C,H and O.



a. Identify the fragment at m/z of 31. 1 mark

_____

b. What is the molecular mass of the molecule? 1 mark

_____

c. The molecule belongs to the homologous family of alkanols. What is its molecular formula? 1 mark

_____

d. The fragment at m/z 29 may fragment further. Write the equation to show this. 1 mark

_____

e. An infrared spectrum of this compound can be used to distinguish it as an alkanol and not a carboxylic acid. What bond and wave number range is absent for an alkanol but present for an acid? 2 marks

_____

Section A: Multiple Choice Answer Sheet

NAME: _____

For each multiple choice question, shade letter of your choice.

Question				
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
18	A	B	C	D
19	A	B	C	D
20	A	B	C	D
21	A	B	C	D
22	A	B	C	D
23	A	B	C	D
24	A	B	C	D
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

Solution Pathway

Note: Teachers will need to provide the VCAA data booklet, unmarked, for student use during this Exam.

SECTION A: Multiple Choice Answers

Question 1 Answer: D

From the Data book, the acidity constants indicate

HF $K_a = 7.6 \times 10^{-4}$

HNO_2 $K_a = 7.2 \times 10^{-4}$

HCN $K_a = 6.3 \times 10^{-10}$

HCl is a strong acid and will have the greatest number of conjugate ions present. HCN will have the least number of conjugate ions present.

Question 2 Answer: D

The key point is the same amount of mole of each acid is required to react with NaOH, the base.

H_2SO_4 is diprotic; therefor requiring double the volume of NaOH.

$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$ Double the amount of NaOH required.

$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H2O(l)$

$CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COO^-Na^+(aq) + H_2O(l)$

CH3COOH is a weak acid. HCl and H2SO4 are strong acids. This is not the key factor.

Question 3 Answer: B

A.CH_4, $\mathbf{C_2H_6}$, $C_6H_5CH_3$, CH_3COOH

B. HNO_3, $Fe_2(SO_4)_3$, $C_6H_5CH_3$ CH_3Cl

C. CH_3OH, C_2H_6O, $CuSO_4.5H_2O$, $\mathbf{C_6H_{12}O_6}$

D**.** $\mathbf{C_4H_8}$, CCl_4, $Mg(OH)_2$, $K_2Cr_2O_7$

Formulas in bold are not in there simplest ration.

Question 4 Answer: A

NH_4SO_4

%(N) = 14/(14 + 4 +32.1+64) x 100 = **12.3%**

NH_4NO_3

%(N) = (2 x 14)/(28 +4 + 48) x 100% = 35.0%

$(NH_4)_3PO_4$

%(N) = (3 x 14)/ (42 + 12 + 19 + 64) x 100% = 30.7%

$(NH_2)_2CO$

%(N) = (2 x 14)/(28 + 4 + 12 + 16) x 100% = 47.7%

Question 5 Answer: C

I Mole

n(Cl2) = m/M = 21.1/71.0 = 0.297mol

11 %w/v

%(w/V) = 21.1/ 9000 x 100% w/v =0.234%

III density

density = m/v = 21.1/9.00 = 2.34 gL^{-1}

Question 6 Answer: C

A. 3.00 mol

3.00/2 x 3120 = 4.680 x 10^3 kJ

B. 100 g

100/ (2x12+6x1) = 3.333mol

3.333/2 x 3120 = 5.199 x 10^3kJ

C. 10.0L at SLC

10.0/24.5 =0.408 mol

0.408/2 x 3120 mol = 6.367 x 10 ^{2}kJ

D. 2.408 x 10^{23} atoms

2.408 x 10^{23}/ 6.02 x 10^{23} = 0.4 mol

0.4 x 3120/2 = 6.240 x 10^2 mol

Question 7 Answer: D

Flame test will identify the presence of sodium but not the concentration of sodium chloride

High Performance Liquid Chromatography will not detect the presence of sodium chloride. HPLC is used for the detection of complex organic substances, NaCl is inorganic.

Question 8 Answer: B

Both I and IV would lead to an underestimate, whilst II and III would lead to an overestimate in the actual mass of sodium chloride. Not weighing to constant mass, would mean the presence of moisture could still be in the sample, not rinsing with a small volume of deionised water could mean the presences of impurities adsorbed onto the surface of the precipitate.

Question 9 Answer: C

The overall equation for the reaction when a battery recharges is:

$2PbSO_4(s) + 2H_2O(l) \rightarrow Pb(s) + PbO_2(s) + 2SO_4^{2-}(aq) + 4H^+(aq)$

pH of the electrolyte is decreasing as the cell recharges.

Question10 Answer: D

A catalyst lowers the activation energy without altering the enthalpy of a reaction.

Question 11 Answer: D

$C_1V_1 = C_2V_2$

$2.00 \times V_1 = 0.01 \times 200$

$V_1 = 1$ mL

Question 12 Answer: A

The final rinsing must be with the solution to be transferred in the pipette. Using distilled water instead of sodium carbonate solution will dilute the standard sodium carbonate. The volume of HCl required will be less. This will lead to an underestimate in the concentration of HCl.

Question 13 Answer: C

The concentration of Na^+ = the concentration of Na_2CO_3 in 100mL

$= 2 \times 0.0500 = 0.100$ mol L^{-1}

$= 0.100 \times 23$ g L^{-1}

$= 2.3$ g L^{-1}

Question 14 Answer: A

Zinc oxide is reduced to zinc by carbon monoxide, therefore carbon monoxide is the reductant.

Question 15 Answer: B

$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ Reduction of copper ion to copper solid is also found in the data book.

Question 16 Answer: D

The overall equation is

$MnO_4^-(aq) + 8H^+(aq) + 5Fe^{2+}(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$

Question 17 Answer: C

R_f of component B is calculated from the ratio of comparison of distances moved and the R_f of component A: R_f of component B = $\frac{3 \times 0.5}{2} = 0.75$

Question 18 Answer: B

Nitrogen is an inert gas and will not react with the compounds. The lower the boiling point indicates a lower molecular mass and therefore a shorter retention time.

With an increase in temperature, molecules will move faster and thus will reduce the retention time.

Question 19 Answer: D

NMR uses energy in the radio frequency which is too low to cause electromagnetic vibration or rotational spins. NMR uses an external magnetic field, and the spinning nucleon of H^1 to identity the chemical environment of the Hydrogen-1 nucleon.

Question 20 Answer: B

Gas chromatography would be used as 1,2-diethanol is a small volatile molecule and can be quantitatively analysed. Mass spectrometry would determine the structure and identity of 1,2-diethanol.

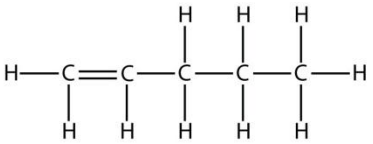
Question 21 Answer: C

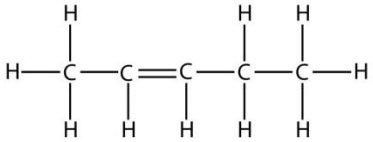
Naming the compound firstly the longest continuous chain of carbon atoms must be identified.

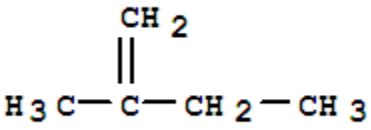
Question 22 Answer: B

Structural isomers refer to compounds that have the same molecular formula but different structural formulae.

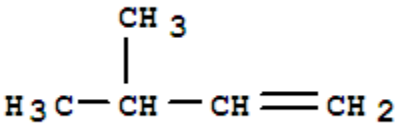
Possibilities for C_5H_{10} are



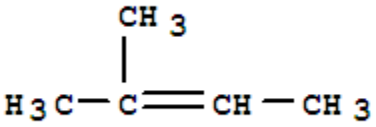




2-methyl-1-butene



3-methyl-1-butene



2-methyl-2-butene

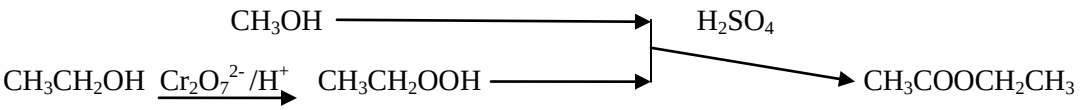
Question 23 Answer: D

$H_2NC_3H_6COOH$ has both a basic - NH_2 amine functional group and an acidic-COOH carboxyl functional group allowing it to react with both a dilute acid, HNO_3 or a dilute base, NaOH.

Question 24 Answer: C

The alcohol forms the prefix of an ester, with the acid following. –ate refers to the ester.

Question 25 Answer: A



Question 26 Answer: D

Using the Data Book:

Methanol = (725/32) = 22.7 kJ/g

Ethene = (1409/.28) = 50.3 kJ/g

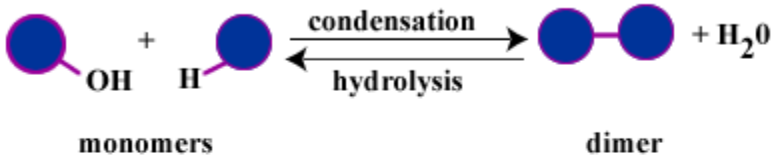
Methane = (889/16) = 55.6 kJ/g

Hydrogen = (286/2) = 143 kJ/g

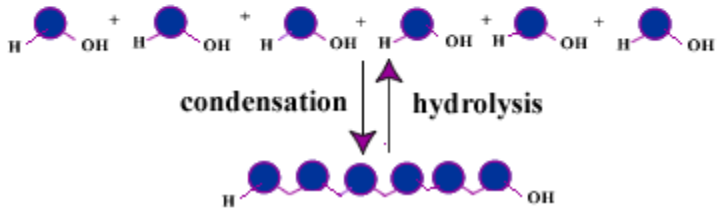
Question 27 Answer: C

Hydrolysis of starch involves breaking the bonds between the glucose molecules with the addition of water to do so.

(1) Dimer



(2) Polymerisation



http://click4biology.info/c4b/3/chem3.2.htm

Question 28 Answer: D

The phosphate group on the backbone of the DNA molecule causes DNA to have an overall negative charge. There it will begin from the negative terminal, connected at W and move towards the positive terminal. Fragment S will have a higher molecular mass than fragment and will thus move at a slower rate through the gel than fragment T from where the samples are loaded.

Question 29 Answer: C

Using the data book, the R groups of the amino acids can be compared. Leucine would be the least soluble at pH 7 as the R group consists of only hydrocarbons, being non-polar and would reduce its solubility in an aqueous solution. Each of the other amino acids contains a polar group.

Question 30 Answer: B

The three hydrogen's of CH_3COO^- appear as the tallest peak as they are all in the same environment and appear as a singlet without another neighbouring H environment.(n + 1 rule = 1).

SECTION B

Question 1

a. 25˚C or 298K

1 atm pressure

1M concentration of solutions (3)

b. $pH = -\log_{10}[H^+] = -\log_{10}[1] = pH = 0$ (2)

5 marks

Question 2

a. Hydrogen peroxide can act both as a reductant and an oxidant. Write the equation when hydrogen peroxide is acting as an oxidant. Include all states and the EMF (V)

$H_2O_2(aq) + 2H^+(aq) + 2e^- \rightarrow 2H_2O\ (l)$; $E^\circ = 1.77$ V (1)

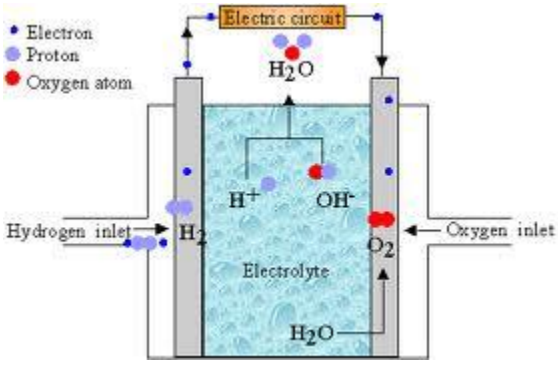
b. Cell Potential Difference = higher half-cell E˚ - lower half-cell E˚ of the electrochemical series.

1.77 – (+0.68) = 1.09 V (1)

c. The rate of reaction is too slow; the electrochemical series does not give information about the rate of a reaction. (1)

3 marks

Question 3



http://www.cheng.cam.ac.uk/research/groups/electrochem/JAVA/electrochemistry/ELEC/l10html/main.html

a. Cell is as galvanic cell. (1)

b. $O_2(g) + 2H_2O(1) + 4e^- \rightarrow 4OH^-(aq)$ (1)

c. $H_2(g) + 2\,OH^-(aq) \rightarrow 2H_2O(1) + 2e^-$ (1)

d. Provides a greater surface to act as a catalyst between the gases, hydrogen and oxygen at each electrode and to allow the transfer of ions produced in the half reactions. The electrolyte increases the rate of reaction. (1)

e. A fuel cell needs a constant injection of reactants, where as a primary cell has a set amount of reactants to use. (1)

f. One of:

Chemical energy of methanol is converted directly to electrical energy and is therefore more efficient than fossil fuel conversions to electrical energy. OR

The fuel cell will generate electricity as long as there is a constant source of methanol. OR

It is readily available at consistent quality as a mass-produced commodity, and in cost-per-unit-of-energy terms compares favourably with petrol and diesel. OR

Methanol is a convenient liquid fuel, easily handled and easily transported, less risk of explosion as with hydrogen gas, eliminating many of the difficulties associated with the provision of compressed gases such as hydrogen where infrastructure is lacking. OR

Methanol can be produced from feedstock such as biomass and waste, in line with the principles of Green Chemistry, reduce, re-use, and recycle. (1)

g. One of (or any reasonable specific statement):

Carbon dioxide is still a product emitted when methanol is used, a greenhouse gas would still be released into the atmosphere. OR

Methanol is still be a non-renewable fossil fuel (unless it is produced as a synthesis gas eg from carbon monoxide and hydrogen) and is not sustainable for large volume production of electricity. OR

Fuels cells generate a direct current, so an inverter is required to change DC to AC at the appropriate voltage. (1) 7 marks

Question 4

a. Energy (J) = mass (g) x S.H.C x Δt (℃)

Methanol	Ethanol	Propanol
= 100.0 x 4.18 x 58.2	= 100.0x 4.18 x 56.7	= 100.0 x 4.18 x 45.5
= 24327.6J	= 23700.6J	= 19019.0J

(3)

b.

Methanol	Ethanol	Propanol
n(methanol) = $\frac{1.59}{32}$	n(ethanol) = $\frac{1.82}{46}$	n(propanol) = $\frac{1.37}{60}$
=0.0497mol	=0.0396mol	=0.0228mol

(3)

Methanol	Ethanol	Propanol
ΔH = q/1000 /n	ΔH = q/1000 /n	ΔH = q/1000 /n
= $\frac{24327.6}{1000x0.0497}$	=$\frac{23700.6}{1000\,x0.0396}$	= $\frac{19019.0}{1000x0.0228}$
= -489kJmol^{-1}	= -599kJmol^{-1}	= -833kJmol^{-1}

(2)

c.

Alkanol	**Experimental data (kJmol^{-1})**	**Data bookΔHc (kJmol^{-1})**
Methanol	-489	-725
Ethanol	-599	-1364
Propan-1-ol	-833	-2016

(1)

The experimental results are consistently less than the expected value for the molar enthalpy of each fuel. (1)

The greater the molar mass of the fuel, the more energy there is available (kJ) per mole of fuel. (1)

d. $C_3H_8O(l) + 4.5\ O_2(g) = 3CO_2(g) + 4H_2O(l)$ ΔH = -146kJmol^{-1}

Or

$2C_3H_8O(l) + 9\ O_2(g) = 6CO_2(g) + 8H_2O(l)$ ΔH = -292kJmol^{-1}

(2)

e. Any 2 of the following or any error that relate directly to the technique of calorimetry.

- The method is very inaccurate because a huge loss of radiant heat energy from the combustion reaction is absorbed by the surrounding air surrounding the flame and not the water.
- The combustion of each fuel is carried out in air and not pure oxygen. This would lead some of the fuel undergoing incomplete combustion, supported by the observation of soot on the bottom of the calorimeter. (The nitrogen in the air would also absorb some of the heat energy).
- There is evaporation of some of the alkanol from the wick of the spirit burner.
- The flame may not have been concentrated at the same point due to draughts.
- There was no stirring of the water, leading to an uneven distribution of the heat.

(2)

f. The same burner and set up, including the volume of water would have been used for each fuel.

(1)

g. $NH_4Cl(s) + H_2O(l) \rightarrow NH_4^+(aq) + Cl^-(aq)$ ΔH is + positive kJ mol^{-1}

(2)

h. Any one of:

- The density of the aqueous solution is assumed to be the same as that for water ie 1g/Ml.
- Adding the solid ammonium chloride has not changed the overall volume.
- The specific heat capacity of the ammonium chloride solution is the same as water i.e. 4.18 J $g^{-1}K^{-1}$

(1)

20 marks

Question 5

Nicholas would **only** be correct if the temperature of the neutral solution was at 298 K or 25^0C.(1) In an aqueous solution, H_3O^+ ions and OH^- ions are always present from the self- ionisation of water.

$$H_2O(l) + H_2O(l) \leftrightarrows H_3O^+(aq) + OH^-(aq)$$

A neutral solution is where the $[H_3O^+] = [OH^-]$ and this only happens at 25℃. (1)

As the temperature changes from 25℃ , $[H_3O^+]$ is not equal to $[OH^-]$, consequently the pH will not equal 7. (1)

David said that a neutral solution was when $[H_3O^+] = [OH^-]$. This is true irrespective of temperature(1). But he is incorrect in saying the pH would equal 7.(1)

Jack was not correct because pH =7 for a neutral solution is true only at 298 K or 25℃. (1)

6 marks

Question 6

a. $Mg(OH)_2(s) + 2\ HCL(aq) \rightarrow MgCl_2(aq) + 2H_2O(l)$

(1)

b. According to the Data Book, the end-point would need to near pH 7, thus phenol red or bromothymol blue. Either answer is acceptable.

(1)

c. n(HCl) = c xV = $3.30 \times 25.6 \times 10^{-3} = 0.08448$ mol = 0.0845 mol (3 sig fig.)

(1)

d.

n(HCl) = n(NaOH) = c x V = $0.0740 \times 27.4 \times 10^{-3} = 0.00203$mol = 2.03×10^{-3}mol

(1)

e.

n(HCl) reacted = n(HCl)initially added – n(HCl) remaining that reacted with NaOH

=0.0448 – 0.0020276 (values left on calculator)

=0.0824524

=0.0825mol (1+ 1 sig. fig) (1)

f.

$n(Mg(OH)_2)$ = n(HCl) x ½ (mole ratio) (1)

= 0.0824524/2

= 0.0412262 mol

$m(Mg(OH)_2$ in one tablet (mg) = n x M /2tablets

=0.412262 x (24.3+ 2x16.0 + 2x 1.0)/2

= 1.20 g (1)

%(m/m) = (1.20 / 1.70) x 100%

=70.1% (1)

(3)

g. A bubble was present below the tap of the burette meant that the volume of NaOH used was actually less than read off the burette. Therefor the mole of NaOH and the mole of HCL would be falsely higher than the actual amount (1). Thus the amount of HCl reacting with the $Mg(OH)_2$ would have been less than the real amount . This would lead to a calculated value of Magnesium Hydroxide being lower than the actual value (1): an underestimate. (2)

h.It was necessary to perform a back titration of magnesium hydroxide as magnesium hydroxide has low solubility in water.

(1)

11 marks

Question 7

a.

$K = [NO_2]^2 / [N_2O_4]$ M

Or
$0.0510 = [NO_2]^2 / [N_2O_4]$ M

(1)

b. $K = [NO_2]^2 / [N_2O_4]$ M

$0.0510 = [NO_2]^2 / [N_2O_4]$

$[NO_2]^2 = 0.0510 \times [N_2O_4]$

$[N_2O_4]$ = n/V
=(10.0/(2x14.0 + 4 x16.0))/5.00
=0.108/5
=0.0217mol L^{-1} (1)

$[NO_2]^2 = 0.0510 \times 0.0217 = 0.0011$
$[NO_2] = \sqrt{0.0011}$
=0.0333 mol L^{-1} (1)

$n(NO_2) = c \times V$
=0.0333 x 5
=0.166 mol (1)
$m(NO_2) = n \times M$
= 0.166 x (14.0 + 2 x 16)
= 7.66g(3 sig figs) (1 + 1 sig figs) (6)

c. As the temperature is increased the colour of the mixture would have an increasing darker brown intensity and will remain the same intensity of brown. (1)

This can be explained according to Le Chatelier's principle. The forward reaction is endothermic. (1) According to Le Chatelier's principle an increase in temperature will favour the forward reaction, the

endothermic direction in order to partially oppose the change. As NO_2 is brown the brown colour intensity will increase then remain constant when the new equilibrium is reached. (1)

10 marks

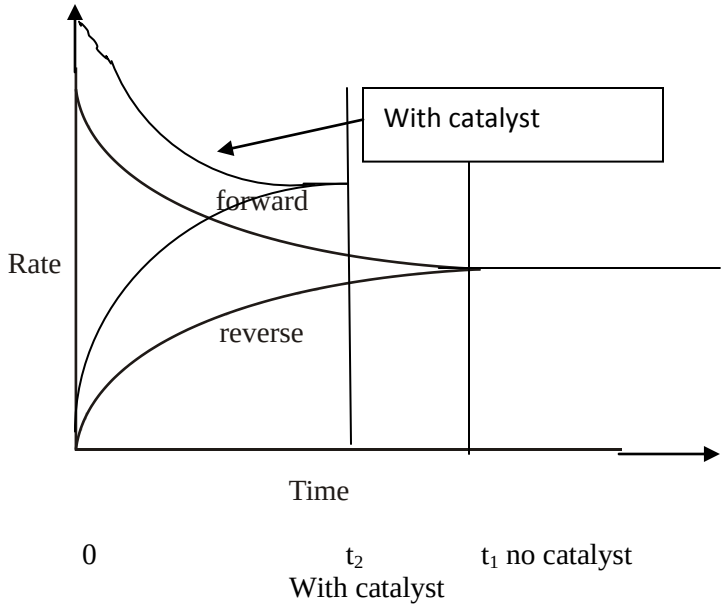
Question 8

Sulphur dioxide and Nitrogen dioxide were admitted to an empty vessel then sealed and allowed to reach equilibrium at temperature X℃, and time, *t* secs.

The equation for the reaction is

$NO_2(g) + SO_2(g) \leftrightarrow NO(g) + SO_3(g)$

a. Use the axes below to sketch a graph of the rates of the forward and back reactions against time, starting at t = 0, t = equilibrium and after equilibrium has been established. Label the axis, the forward and reverse reaction, indicate the time where equilibrium is established



Two curves – one labeled 'forward' starting up high up y-axis and one labeled 'reverse'.

Starting from zero; curves merge and become horizontal; (1)

forward reaction:

highest concentration, thus rate high to begin with;
as reaction proceeds, concentrations decrease, so does rate (1).

reverse reaction:

zero rate initially/at t = 0 (since no products present); (1)
rate increases as concentration of products increases;
equilibrium established when rate of forward reaction = rate of reverse reaction;line is horizontal.

t1 is labelled as initial equilibrium (1).

b. Equilibrium is reached at an earlier time, t2 (1). The forward reaction occurs at a greater rate and the back commences and continues at a greater rate (1).

c. A catalyst speeds up both the forward and the reverse reaction, at the same rate. The equilibrium may be reached sooner but a catalyst does not alter the position of the equilibrium (1). The catalyst provides and alternative pathway for the reaction that has a lower activation energy (1).

d. As the temperature is increased, particles move faster. The reactants have more kinetic energy (1) and thus there are more successful or fruitful collisions per unit of time (1).

10 marks

Question 9

a. $Pb^{2+}(aq) + SO_4^{2-}(aq) = PbSO_4(s)$ (1)

b. The filtered precipitate was rinsed with deionised water. It was dried in an oven at 96℃. Over 5 days the following weighing's were recorded.

Sample of Lead precipitate	Mass (g)
1	0.4732
2	0.4616
3	0.4612
4	0.4613
5	0.4620

Calculate the mass (g) of the lead in the precipitate. Select values with the least range.
Average mass of the $PbSO_4(s)$ = (0.4616 + 0.0.4612 +0.4613)/3
= 0.4614g (1)

$n(PbSO_4) = m/M$
=0.4614/(207.2+32.1+4x16.0)
= 0.001521mol
$= 1.521 \times 10^{-3}$ mol (1)

$m(Pb^{2+}) = n \times M$
= 0.001521 x 207.2
=0.3152g (1)

c. $n(Pb^{2+}) = n(PbSO_4) = 1.521 \times 10^{-3}$ mol
$c(Pb^{2+}) = n/V$
$= 1.521 \times 10^{-3}$ mol/0.250
$= 6.085 \times 10^{-3}$ mol L^{-1} (1)

d. $c(Pb^{2+}) = 6.085 \times 10^{-3}$ mol L^{-1}
$m(Pb^{2+}) = n \times M / L$
$=6.085 \times 10^{-3} \times 207.2$
$=1.261 gL^{-1}$
$=1.26 \times 10^{3} mgL^{-1}$ (1)

d. The maximum level of lead in safe drinking water is 0.015ppm = $0.015 mgL^{-1}$. The polluted water well above and unfit for human consumption. (1)

e. The result would add to the mass of the precipitate and result in an over-estimate of the true mass of the Pb^{2+} content. (1)

f. $Pb^{2+}(aq) + SO_4^{2-}(aq) = PbSO_4(s)$

$n(Na_2SO_4) = n(PbSO_4)$
$= 1.521 \times 10^{-3}$ mol (1)
$V(Na_2SO_4) = n/c$
$= 1.521 \times 10^{-3}/0.2$
$= 7.65mL$ (1)

g. The precipitating agent should be in excess to ensure complete precipitation of all the Pb^{2+} ions. (1)

10 marks

Question 10

a. The wavelength from the lamp must match the wavelength to be absorbed by the metal calcium (1).
b. The aspirator burner evaporates water from the sample and the calcium ions are reduced to a vapour of atoms (1). The electrons from the calcium atoms absorb radiation coming from the hollow cathode lamp (1). (The amount of absorbance is measure by the detector).

c. Line of best should be drawn, with the calcium concentration(mgL^{-1}) on the X-axis and absorbance on the y-axis. (2 marks for graph labelled correctly)

From the graph the calcium concentration will read 2.8 mgL^{-1} (+/- 0.1) in the diluted milk sample (1).

d. The total dissolved calcium, mgL^{-1}
2.8 x 100/1 x 10/2 (1)
$=1400 mgL^{-1}$
$=1.4 \times 10^3 mg\ L^{-1}$ 2 sig figs (1)

e. Calculate the percentage, (m/v) of calcium in the milk sample
$1.4 \times 10^3 mg\ L^{-1}$
$=1.4g\ L^{-1}$
=0.14% (m/v) (1)

f. There must have been calcium ions in the blank solution and the AAS spectrophotometer was not correctly calibrated to zero absorbance prior to running the samples (1).
g. A calcium cathode lamp emits a specific wavelength of light that can only be absorbed by other calcium atoms or ions. Hence sodium ions do not interfere (1). 12 marks

Question 11

a. CH_2OH^+ the fragment must have the plus charge included. (1)
b. Molecular mass = 60 g mol^{-1} (1)
c. C_3H_8O (1)
d. $CH_3CH_2^+ \rightarrow CH_3^+ + \cdot C H_2$ (1)
e. The bond is C=O Wave number (cm^{-1})range is1670 – 1750 (2)

6 marks