2019

Higher School Certificate

Year 12 Trial Examination

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board approved calculators may be used
- Write using black pen
- Draw diagrams using pencil
- A ruler is required

Write your NESA number in the spaces provided.

Total marks – 100

Weighting – 30%

Use the data and formula sheet provided

Section I – 20 marks (pages 2 – 8)

- Attempt questions 1 – 20.
- Allow about 35 minutes for this section.

Section II – 80 marks (pages 9 – 26)

- Attempt questions 21 – 35
- Allow about 2 hours and 25 minutes for this section.

This paper MUST NOT be removed from the examination room

Section I – Multiple Choice (20 marks)
Attempt Questions 1 – 20
Allow about 35 minutes for this section

Use the multiple-choice answer sheet for Questions 1 – 20.

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1 Indigenous Australians detoxified seeds of cycad plants, which contain the toxin cycasin, to allow the seeds to be eaten safely.

One method used in the detoxification process involved crushing the seeds to expose the inner kernels and then soaking the crushed seeds in water.

The property of the cycasin toxin upon which this method relies is:

A. the higher density of the toxin compared to water.

B. the reactivity of the toxin with water.

C. the solubility of the toxin in water.

D. the immiscible nature of the toxin in water.

2 Which one of the following is an example of an equilibrium system?.

(A) Burning propane gas in a barbeque.

(B) A saturated solution of sodium chloride.

(C) Reacting magnesium with oxygen in a Bunsen flame.

(D) The production of glucose by photosynthesis

3 Which of the following statements is true of a system at equilibrium?

A. The concentration of reactants and products are equal.

B. The forward and reverse reactions are no longer occurring.

C. The rates of the forward and reverse reactions are equal.

D. The concentration of reactants and products changes constantly.

4 Which of the following reactions would represent a dynamic equilibrium?

A. Steel wool being burnt in a Bunsen Burner flame

B. Granulated zinc being placed into a beaker with 100.00 mL of 1.0 $mol.L^{-1}$ HCl

C. 100.00 mL of 1.0 $mol.L^{-1}$ HCl is reacted with 100.00 mL of 1.0 $mol.L^{-1}$ NaOH

D. 5 drops of 0.1 $mol.L^{-1}$ Lead nitrate is reacted with 5 drops of 0.1 $mol.L^{-1}$ Silver chloride

5 The pH of pure water at 50°C ($K_w = 5.5 \times 10^{-14}$) is:

A. 7

B. 6.63

C. 13.2

D. 13.6

6 The pH of a 0.0001 mol L^{-1} solution of a monoprotic acid was measured by a student and found to be 4.

What proportion of the acid molecules has been converted to ions?

(A) 0%

(B) 4%

(C) 96%

(D) 100%

7 What is the concentration of H_3O^+ in a solution with a pH of 2.38?

A. 0.38 mol L^{-1}

B. 11.62 mol L^{-1}

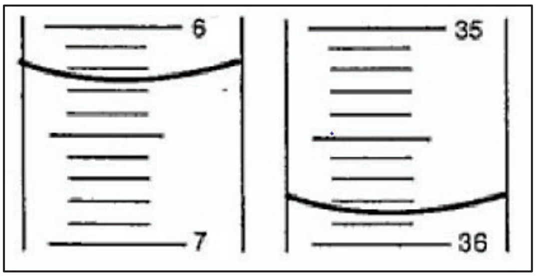
C. 4.17×10^{-3} mol L^{-1}

D. 2.40×10^{-12} mol L^{-1}

8 Read the information box below about uncertainty.

- Every measurement has an associated uncertainty value.
- For glassware, the uncertainty value is taken as half the value of the smallest interval.
- Any uncertainty in measurements should be added when the measurements themselves are added or subtracted.

The diagram below shows the level of acid before and after the acid was added to reach endpoint with a base.



Which of the following is the correct titre, with its uncertainty?

A. 29.6 mL

B. 29.60 ± 0.05 mL

C. 29.62 ± 0.05 mL

D. 29.60 ± 0.10 mL

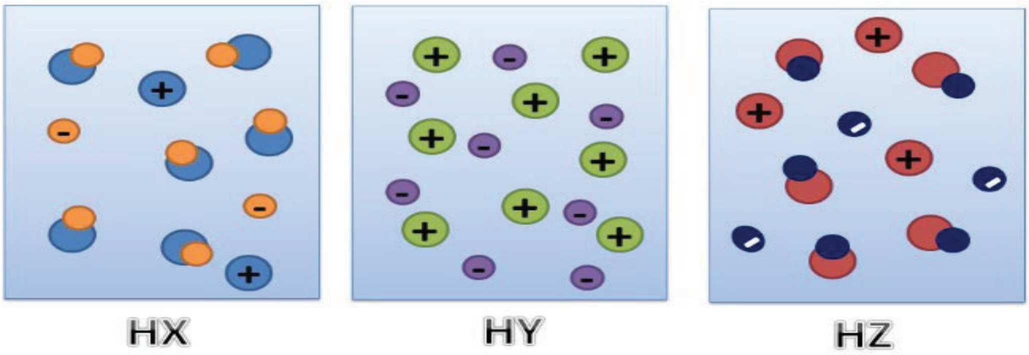
9 The table below shows pK_{ind}, the pH range, and the colour changes of three indicators.

Indicator	pK_{ind}	pH range	colour at lower pH	colour at higher pH
bromophenol blue	4.0	3.0 - 4.6	yellow	blue
methyl red	5.1	4.2 - 6.3	red	yellow
phenolphthalein	9.3	8.3 - 10.0	colourless	red

At a pH of 4 which option below correctly identifies the colour of the solution:

	Bromophenol blue	**Methyl red**	**Phenolphthalein**
(a)	yellow	red	colourless
(b)	yellow	yellow	colourless
(c)	green	orange	colourless
(d)	green	red	colourless

10 Three solutions of acids, HX, HY and HZ, are represented by the following diagrams. For clarity, water molecules have not been shown.



The acids, in order of increasing acid strength, are

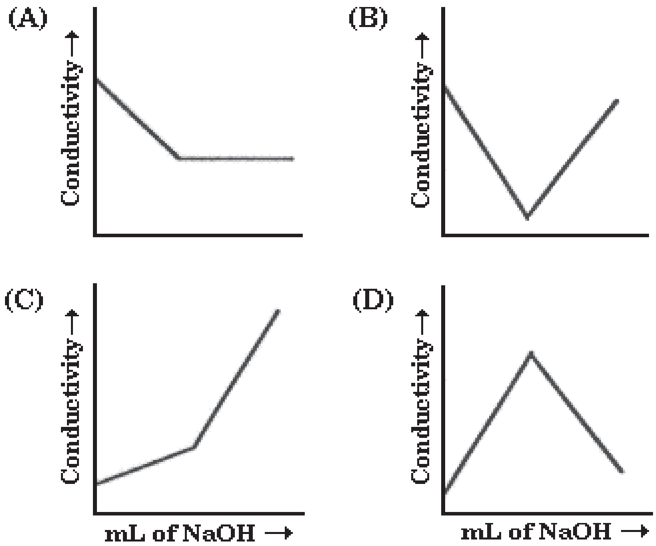
(A) HX, HY, HZ

(B) HZ, HX, HY

(C) HX, HZ, HY

(D) HY, HZ, HX

11 Which graph best represents the electrical conductivity changes that occur when an aqueous solution of acetic acid is titrated with an aqueous solution of sodium hydroxide, NaOH?



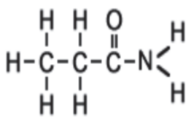
12 Below is a table of reactions involving organic compounds.

Reaction	Prod uct
ethene + hydrogen chloride	1
ethanal + permanganate ion	2
ethanol + ethanoic acid	3
ethanoic acid + sodium carbonate	4

Which row of the table below correctly identifies a product from each reaction?

	Product 1	Product 2	Product 3	Product 4
(A)	chloroethane	ethanoic acid	ethanal	sodium ethanoate
(B)	chloroethene	ethanoic acid	ethyl ethanoate	carbon dioxide
(C)	chloroethane	ethanal	ethanoate ion	carbon dioxide
(D)	chloroethane	ethanoic acid	ethyl ethanoate	carbon dioxide

13 The correct name of the following organic compound is



A. Propanamide

B. Propanamine

C. Propanol

D. Propanoic acid

14 Which of the following compounds can be derived both from fossil fuels and from biomass materials?

A. Ethanol

B. Octane

C. Glucose

D. Cellulose

15. Which of the following lists contains members of the same homologous series?

(A) C_2H_6, C_4H_{10}, C_6H_{14}

(B) C_2H_2, C_2H_4, C_2H_6

(C) C_2H_5Cl, C_2H_5OH, $C_2H_5NH_2$

(D) CH_3Cl, CH_2Cl_2, $CHCl_3$

16 The correct combination of natural organic acid and a natural organic base is

	Organic acid	Organic base
A	Citric acid	Thymine
B	Sulfuric acid	Cytosine
C	Ethanoic acid	Sodium hydroxide
D	Oxalic acid	Ethanamine

17 When a sample of NO_2 *(g)* is placed in a container, the following equilibrium is rapidly established:

$$2NO_2\,(g) \rightleftharpoons N_2O_4\,(g)$$

If this equilibrium mixture is a darker colour at high temperatures and at low pressures, which of these statements about the reaction is correct?

A. The reaction is exothermic and NO_2 is darker in colour than N_2O_4.

B. The reaction is exothermic and N_2O_4 is darker in colour than NO_2.

C. The reaction is endothermic and NO_2 is darker in colour than N_2O_4.

D. The reaction is endothermic and N_2O_4 is darker in colour than NO_2.

18 Which option represents K eq for the reaction below: (Module 5 IQ 3)

$2SO_{3\,(g)} \leftrightharpoons 2SO_{2\,(g)} + O_{2\,(g)}$

A. $2[SO_2][O_2] / 2[SO_3]$

B. $[SO_2]^2 [O_2] / [SO_3]^2$

C. $[SO_3]^2 / [SO_2]^2 [O_2]$

D. $2[SO_3] / 2[SO_2][O_2]$

19 The equilibrium constant for the reaction below has an equilibrium constant K_1.

$\mathbf{H_2}\,(g) + \mathbf{I_2}\,(g) \rightleftharpoons 2HI\,(g) \quad K_1 = 159$ at 500K

At the same conditions of temperature and pressure, what is the equilibrium constant for the reaction:

$HI\,(g) \rightleftharpoons \frac{1}{2}\mathbf{H_2}\,(g) + \frac{1}{2}\mathbf{I_2}\,(g)$

A. 0.00629

B. 0.0793

C. 12.6

D. 79.5

20 The concentration of reactants and products were studied for the following reactions:

$H_2(g) + F_{2(g)} \rightleftharpoons 2HF(g)$; $K_{eq} = 313$ at 25°C

In an experiment, the initial concentrations of the gases were
$[H_2] = 0.0120$ M, $[F_2] = 0.0200$ M, and $[HF] = 0.500$ M.

When the reaction reaches equilibrium at 25°C, the concentration of HF will be:

A. 0.550 M

B. 0.25 M

C. less than 0.500 M

D. between 0.0500 M and 0.550 M

End of section 1

NESA number: ....

HSC Course

Chemistry 2019

Trial Examination

Answer Part A on this sheet
Select the alternative A,B,C or D that best answers the question.
Fill in the response oval completely
Eg: 2 + 4 =

(A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ⊗ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow indicating the correct response.

A ● B ⊗ C ○ D ○

Correct

Q	A	B	C	D
1	○	○	○	○
2	○	○	○	○
3	○	○	○	○
4	○	○	○	○
5	○	○	○	○
6	○	○	○	○
7	○	○	○	○
8	○	○	○	○
9	○	○	○	○
10	○	○	○	○
11	○	○	○	○
12	○	○	○	○
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14	○	○	○	○
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17	○	○	○	○
18	○	○	○	○
19	○	○	○	○
20	○	○	○	○

Outcome	Questions									Mark
Knowledge and Understanding	1-4	13-20	23	24	26	27	28	30	32	
	/4	/8	/4	/6	/7	/6	/3	/4	/8	/50
Working Scientifically	5-12	21	22	25	29	31	32	33	35	
	/8	/6	/4	/4	/6	/3	/7	/6	/6	/50
									TOTAL	/100

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Section II - 80 marks
Attempt Questions 21-35
Allow about 2 hours and 25 minutes for this part

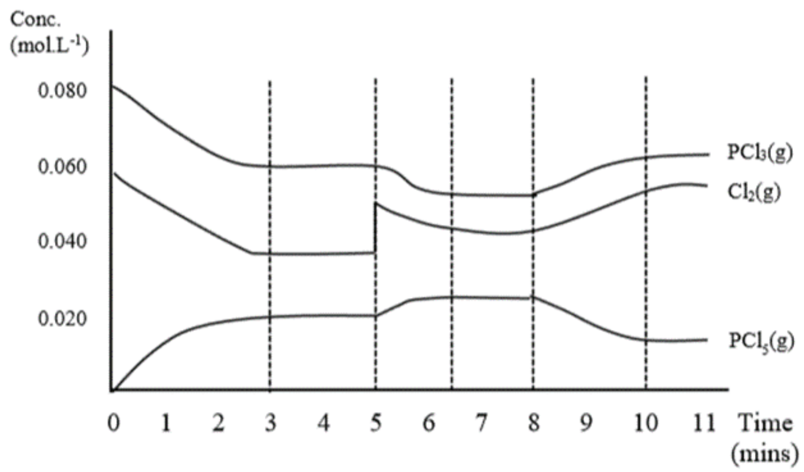
Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.

Question 21 (6 marks) **Marks**

Consider the graph below, which shows the concentration of each species in the equilibrium system:

$$PCl_3(g) + Cl_2(g) \leftrightarrow PCl_5(g) \quad \Delta H = -92 \text{ kJ/mol}$$

This is measured over 11 minutes, during which time various changes are imposed on the system.



(a) When does the system first reach equilibrium? Justify your answer. **2**

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(b) What change was imposed at t = 5 minutes? Explain what would happen to the rates of the forward and reverse reactions immediately after this change. **2**

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Question continues on next page…

Question 21 (continued) **Marks**

(c) Calculate the value of K for the reaction using the data from t = 4 minutes. **2**

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Question 22(4 marks)

A student was provided with a beaker containing a blue coloured solution of cobalt (II) chloride and was asked to investigate the following equilibrium reaction:

$$Co(H_2O)_6^{2+}{}_{(aq)} + 4Cl^-{}_{(aq)} \rightleftharpoons CoCl_4^{2-}{}_{(aq)} + 6H_2O_{(l)} \quad \Delta H = +$$

Pink **Blue**

(a) 5 mLs of cobalt (II) chloride solution were poured into a test tube with 5 drops of 4M HCl.

Use Le Chatelier's principle to predict the impact on this reaction and describe its appearance. **2**

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(b) Outline a procedure the student could follow to investigate the impact of temperature changes on this reaction. **2**

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Question 23 (4 marks) **Marks**

Carbon monoxide reacts with chlorine to produce carbon oxychloride as shown by the following equation.

$$CO_{(g)} + Cl_{2(g)} \rightleftharpoons COCl_{2(g)} \quad \Delta H = -5 kJ\ mol^{-1}$$

A 10 litre reaction vessel initially contained 2.0 moles carbon monoxide and 5.0 moles chlorine gas at 200°C. When the reaction reached equilibrium, there was 1.0 mole of carbon monoxide remaining.

(a) Calculate the equilibrium concentration of carbon monoxide, chlorine and carbon oxychloride. **2**

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(b) Write the equilibrium expression for this reaction then calculate the value for K_{eq}. Show relevant working. **2**

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Question 24(6 marks) **Marks**

The K_{sp} for calcium fluoride is 1.00×10^{-11} at 25.00°C.

(a) Calculate the solubility of calcium fluoride in $mol.L^{-1}$ in water at 25.00°C. **3**

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(b) Consider the reaction below:

$$CH_4\,(g) + 2H_2S\,(g) \rightleftharpoons CS_2(g) + 4H_2\,(g)$$
$$K_{eq} = 3.6 \text{ at } 1173K$$

Given the concentrations recorded in the table:

Substance	Concentration mol.
CH_4	1.07
H_2S	1.20
CS_2	0.90
H_2	1.78

Explain whether the reaction is at equilibrium or favours the reactants or products. **3**

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Question 25 (4 marks) **Marks**

The boiling points of organic acids increases with increase in Molar Mass.

(a) Plot a graph using the data given in the table. **3**

Organic acid	Molar mass (amu)	Boiling point (^0C)
Methanoic acid	46	101
Ethanoic acid		118
Propanoic acid	74	?
Butanoic acid	88	163
Pentanoic acid	102	186

(b) Using the graph, predict the boiling point of Propanoic acid. **1**

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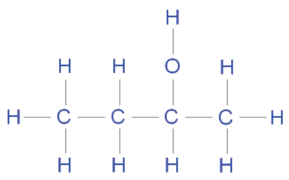
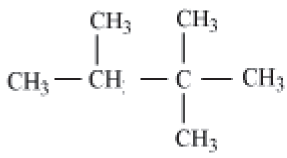
Question 26 (7 marks) **Marks**

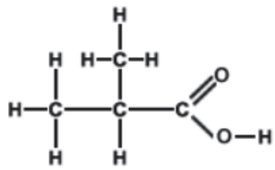
(a) Using IUPAC nomenclature, name the compounds shown below. **3**



Compound 1



Compound 2



Compound 3

Compound 1 ……………………………………………………………………

Compound 2 ……………………………………………………………………

Compound 3 ……………………………………………………………………

(b) Compare the intermolecular forces in the above 3 molecules and predict the order of boiling points (lowest to highest) of these molecules. Explain your prediction. **4**

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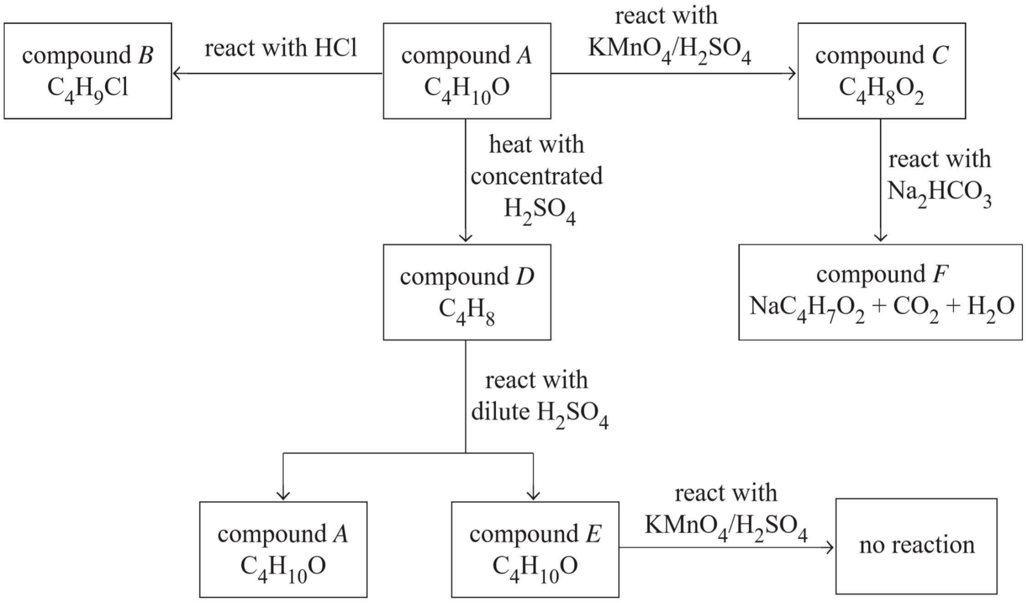
Question 27 (6 marks) **Marks**

The flow chart shows the reactions of six different organic compounds.



Complete the table by drawing the structural formulae for the compounds and justifying your answers with reference to the information provided. **6**

Compound	*Structural formula*	*Justification*
Compound A $C_4H_{10}O$		
Compound B C_4H_9Cl		
Compound C $C_4H_8O_2$		
Compound D C_4H_8		
Compound E $C_4H_{10}O$		
Compound F $NaC_4H_7O_2$		

Question 28 (3 marks) **Marks**

Describe the relationship between the structure of soaps and their cleaning action. **3**

Include an appropriate diagram with your answer.

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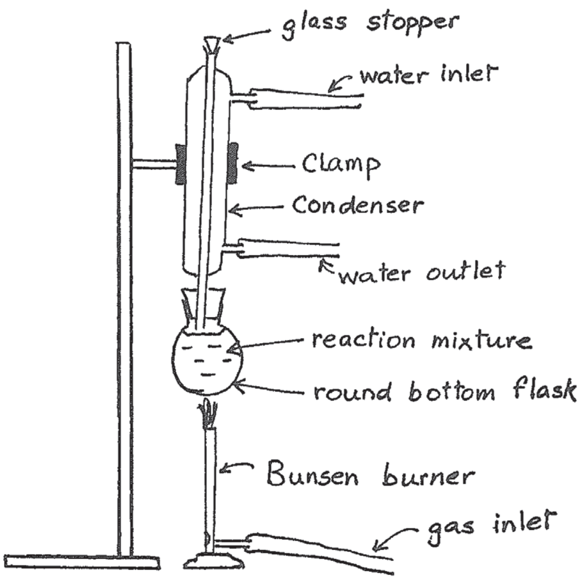
Question 29 (6 marks)

(a) In a student's report of the above experiment , the following diagram was included. As shown, the apparatus is both ***dangerous*** and ***inefficient***.
List THREE aspects for this set-up which represent bad techniques and give reasons for your choices. **6**



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Question 30 (4 marks) **Marks**

An equimolar solution of carbonic acid and hydrogen carbonate ions has reached equilibrium with a pH of 6.4.

$$H_2CO_{3(aq)} + H_2O_{(l)} \rightleftharpoons HCO_3^-{}_{(aq)} + H_3O^+{}_{(l)}$$

(a) What would happen if a small volume of dilute acid or base was added to this solution? **2**

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(b) Identify a natural buffer and describe its importance in a natural system **2**

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Question 31 (3 marks) **Marks**

A student used indicators to determine whether three colourless solutions were acidic or basic. The indicators used are shown in the table.

Indicator	*Colour Change*	*pH range*
Methyl orange	red to yellow	3.2 – 4.4
Methyl red	red to yellow	4.8 – 6.0
Thymol blue	yellow to blue	8.0 – 9.6
Alizarin	red to purple	11.0– 12.4

Samples of each solution were tested with the indicators. The colours of the resulting solutions are shown in the table.

Indicator Added	*Colour of solution A*	*Colour of solution B*	*Colour of solution C*
Methyl orange	yellow	yellow	yellow
Methyl red	yellow	yellow	yellow
Thymol blue	blue	Blue	yellow
Alizarin	purple	red	red

The student conclude that each of the three solutions tested was basic. Assess the validity of this conclusion

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Question 32 (7 marks) **Marks**

A student was asked to determine the mass of $CaCO_3$ present in a 2.25 gram sample of chalk. The chalk reacted with 100 mL of a 1.00 M HCl solution. After the bubbling stopped, excess HCl remained. The excess HCl was titrated with 1.0 M NaOH. The average titre was 17.15 mLs.

(a) Calculate the number of moles of sodium hydroxide which reacted with the excess HCl. **1**

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(b) Determine the number of moles of HCl added to the chalk sample and use this to calculate the actual number of moles of calcium carbonate present in the sample. **4**

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(c) Calculate the mass of calcium carbonate present in the 2.25 g chalk sample. **2**

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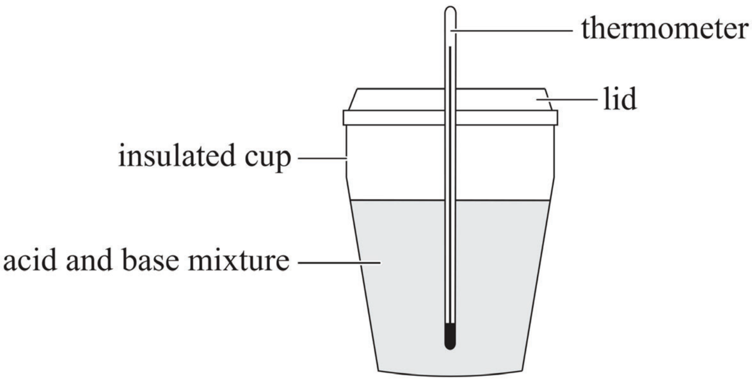
Question 33 (6 marks) **Marks**

The diagram shows a coffee cup calorimeter used by a student to measure the enthalpy of neutralisation of an acid–base reaction.



120 mL of 0.500 $molL^{-1}$ sodium hydroxide was added to 60.0 mL of 0.500 $molL^{-1}$ sulfuric acid. Both solutions were at a temperature of 24.2°C. After mixing, the final temperature was 26.3°C.

Calculate the enthalpy change per mole of water formed in this reaction. **3**

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Discuss the reliability of the student's experiment and results 3

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Question 34 (8 marks) **Marks**

Investigations by various scientists over time have improved the accuracy and depth of knowledge about acids. Arrhenius and Brønsted and Lowry have contributed to our understanding of the nature of acids and bases. With reference to their work, outline the contribution of each to the current understanding of acids and bases. Explain the limitations of each model. Include equations in your response. **8**

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Question 35 (6 marks) **Marks**

A teacher asks two groups of students (Group A and Group B) to titrate a solution of approximately 0.1M hydrochloric acid, using a standard solution of NaOH(aq).

Group A obtains the correct value, 0.1015M.
The result obtained by Group B, 0.1205 was incorrect.

(a) Identify an incorrect rinsing procedure that could have led to Group B's value, and explain why it gives a higher value for the concentration of HCl. **3**

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(b) The teacher also has an approximately 0.1M solution of ethanoic acid.

Explain why measuring the pH is an effective way of distinguishing between the HCl and ethanoic acid, whereas titrating each acid against NaOH will not work. **3**

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END OF EXAMINATION

ADDITIONAL WRITING SPACE

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
C	**B**	**C**	**D**	**B**	**D**	**C**	**D**	**D**	**C**	**C**	**D**	**A**	**A**	**A**	**A**	**A**	**B**	**B**	**C**

21.a.

Marking Criteria	Marks
• Identifies t = 3 minutes with a correct justification.	**2**
• Identifies t = 3 minutes.	**1**

The system first reaches equilibrium at t = 3 minutes. This is clear from the graph because it is when the concentrations of each species in the system start to remain constant.

21.b.

Marking Criteria	Marks
• Identifies that the concentration of Cl_2 was increased and explains subsequent changes in rates until t=7min or “until new equilibrium is established”	**2**
• Identifies that concentration of CL_2 was increased OR describes changes in the rates of the forward and reverse reactions.	**1**

The concentration of Cl_2 gas was increased, and more collisions between the reactants will immediately increase the rate of the forward reaction (we ‘see’ this as a shift to the right, which is why the [Cl_2] falls after the initial spike. Since the forward reaction is favoured, reactant particles then fall, reducing the rate of the forward reaction, while the rate of the reverse speeds up, due to more collisions in products made from the initial shift. The rates equalise at 6.5 min and remain equal until 7min (i.e. system at equilibrium).

21.c.

Marking Criteria	Marks
• Correctly calculates K using concentration values for t = 4 minutes.	**2**
• Writes the correct equilibrium constant expression.	**1**

$K = [PCl_5]/[PCl_3][Cl_2]$
K = 0.02/(0.04x0.06)
K = 8.33

22 (a)

Criteria	Marks
• Uses le Chatelier's principle to predict impact of adding HCl • Correctly describes appearance of solution	2
• Uses le Chatelier's principle to predict impact of adding HCl OR • Correctly describes appearance of solution	1

Sample answer:

The addition of HCl raises the concentration of chloride ions causing the equilibrium to shift to the right to reduce the concentration of the additional chloride ions as predicted by Le Chatelier's principle. This solution would change from blue to a deeper blue in colour as more $CoCl_4^{2-}$ forms (or remains blue)

22 (b)

Criteria	Marks
• Outlines a valid procedure	2
• Provides some simple steps	1

Sample answer:

1. Pour 5 mL of Blue coloured solution into three separate test tubes.

2. Label test tube 1 and keep at room temperature as a control.

3. Label test tube 2 and place in a hot water bath.

4. Label test tube 3 and place in an ice/water bath

5. Wait 5 minutes and record colour changes.

Question 23 (4 marks)

(a)

Criteria	Marks
• Calculates correctly all initial concentrations and equilibrium concentrations of each species	2
• Calculates initial concentrations correctly with one error in equilibrium concentrations	1

Sample answer:

Volume of reaction vessel = 10 litres

species	Moles	initial conc. mol L^{-1}	equilibrium conc. mol L^{-1}
CO	2.0	0.20	0.10
Cl_2	5.0	0.50	$[Cl_2]$ - $[COCl_2]$ 0.50 - 0.10 = 0.40
$COCl_2$	0.0	0	0.20-0.10 =0.10

(b)

Criteria	Marks
• Shows correct equilibrium expression and working out showing correct equilibrium constant	2
• Shows correct equilibrium expression shown OR equilibrium constant	1

Sample answer:

$$k = \frac{[COCl_2]}{[CO]\,[Cl_2]} = \frac{0.1}{0.1 \times 0.40} = 2.5$$

Question 24

Marks	
Answer CaF_2 (aq) <-> Ca^{2+} (aq) + 2 F^- (aq) Ksp = $[Ca^{2+}]$ $[F-]^2$ $x.(2x)^2 = 1.00 \times 10^{-11}$ $x = 1.4 \times 10^{-4}$ $mol.L^{-1}$ Solubility of calcium = solubility of calcium fluoride = 1.4×10^{-4} $mol.L^{-1}$	3
As above but Ksp expression is not provided	2
1 correct step	1

Marks	
Answer Q= 5.86 *>K thus backwards reactions.* *Writes expression for Q, correctly substitutes values, calculates Q correctly and states larger than K thus system is favouring reverse reaction*	*3*
As above but does not include the Q expression	*2*
1 correct step	*1*

Question 25

Marking criteria	Marks
Axis labelled with correct units. Appropriate scale for both axis. Plots joined with an appropriate straight line. An appropriate title.	3
Any one of the above missing	2
A recognisable graph	1

Generally well done

You should have been able to work out the Molar mass of Ethanoic acid and know that it was 60. This point should have been plotted

b)

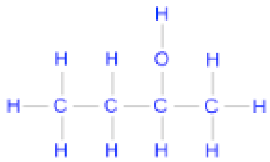
Marking criteria	Marks
Correct value from the graph	1

Examiners comments:

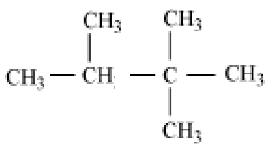
Needed to demonstrate boiling point of propanoic acid using graph

Question 26 – 7 marks (a) (3 marks)

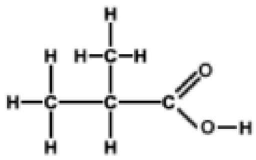
(a) Using IUPAC nomenclature, name the compounds shown below. **3**



Compound 1



Compound 2



Compound 3

Compound 1 ....

Compound 2 ....

Compound 3 ....

Outcomes Assessed: CH12–7, CH12–14
Targeted Performance Bands: 3-5

Criteria	Marks
• Names THREE compounds correctly	3
• Names TWO compounds correctly	2
• Names ONE compound correctly	1

Sample answer

Compound 1 = butan-2-ol
Compound 2 = 2,2,3-trimethylbutane
Compound 3 = 2-methylpropanoic acid

Examiners Comments:
Mainly related to incorrect naming of 2,2,3 trimethylbutane
Check for the longest chain containing the functional group

(b) (4 marks)

Compare the intermolecular forces in the above 3 molecules and predict the order of boiling points (lowest to highest) of these molecules. Explain your prediction.

Outcomes Assessed: CH12–7, CH12–14
Targeted Performance Bands: 3-5

Criteria	Marks
• Predicts the correct order of boiling points • Explains thoroughly the impact of the different intermolecular forces • Identifies that Compound 1 has hydrogen bonding as the strongest intermolecular force • Identifies that Compound 2 has dispersion (temporary dipole-dipole forces) only • Identifies that Compound 3 has hydrogen bonding (2 hydrogen bonds form between adjacent molecules)	4
• Predicts the correct order of boiling points • Explains thoroughly the impact of the different intermolecular forces • Identifies the intermolecular forces in 2 of the 3 compounds	3

• TWO of:
  ◦ Predicts the correct order of boiling points
  ◦ Explains thoroughly the impact of the different intermolecular forces
  ◦ Identifies the intermolecular forces in 2 of the 3 compounds
	2

• ONE of:
  ◦ Predicts the correct order of boiling points
  ◦ Explains thoroughly the impact of the different intermolecular forces
  ◦ Identifies the intermolecular forces in 1 of the 3 compounds
	1

Examiners Feedback

Students need to read the question and answer from the lowest to the highest.

Lack of understanding of Hydrogen bonding being a strong bond and if there is more than one site of bonding it will have a higher boiling point.

Students generally did not refer to structure of molecule

Sample answer

The order of increasing boiling point is Compound 2, Compound 1, Compound 3.

The stronger the intermolecular forces, the higher the boiling point, as greater energy is needed to separate the liquid molecules to form a gas.

Compound 2 is non-polar and has only weak intermolecular forces (dispersion or temporary dipole-dipole forces) caused by the electrical interaction of molecules as they collide (protons from 1 molecule being attracted to electrons from the other as the molecules are temporarily distorted on collision).

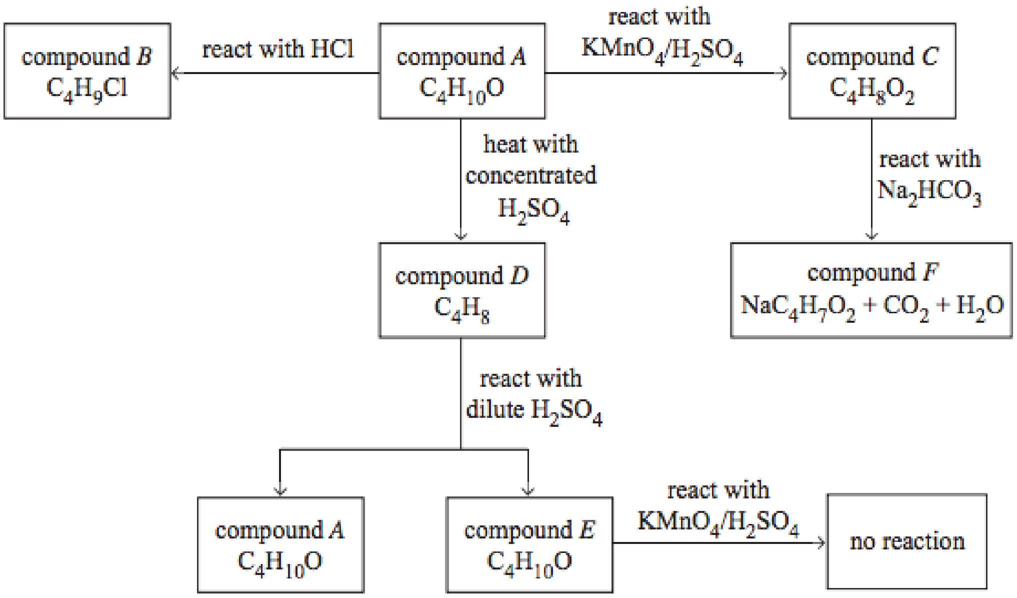
Compound 1 is polar and would experience hydrogen bonding forces, as well as weaker temporary and permanent dipolar forces) as molecules interact. These are strong intermolecular forces where the electronegativity of the oxygen results in a very polar bond with hydrogen in the O–H group. This hydrogen is attracted to the oxygen of a neighbouring alcohol molecule. The geometry of the molecule only allows 1 H-bond per pair of molecules at any instant.

Compound 3 is an acid and has the very polar – COOH functional group. The hydrogen atom of the –COOH can form a hydrogen bond with an oxygen of the neighbouring acid molecule. The planar nature of this –COOH group allows 2 H-bonds per pair of molecules.

Hence the intermolecular forces and thus boiling points are highest in Compound 3 and lowest in Compound 2.

Question 27 (6 marks)

The flow chart shows the reactions of six different organic compounds. **6**



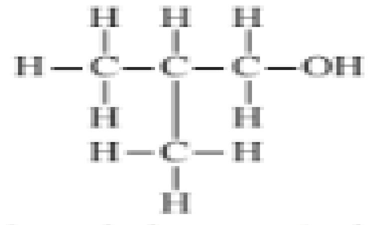
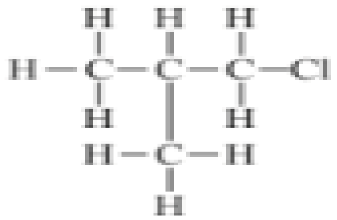
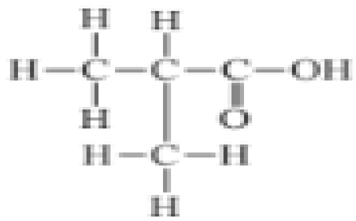
Complete the table by drawing the structural formulae for the compounds and justifying your answers with reference to the information provided.

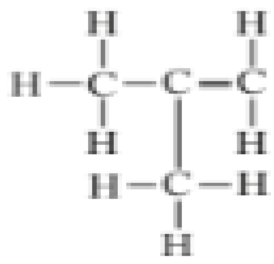
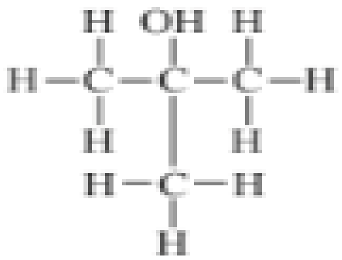
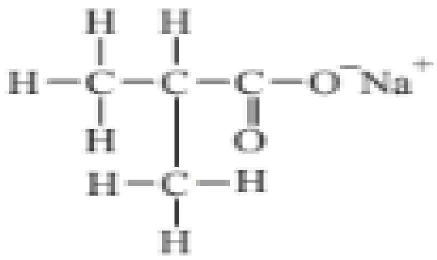
Examiners Comments:
Most students did not recognise that it was a tertiary alcohol and therefore did not draw correct diagrams with branching indicated.

Students need to review Sodium salts of acids

If reasoning is correct for all but branching not shown in diagrams (therefore no acknowledgement of tertiary alcohol) maximum is 3. This is because none of the diagrams are correct.

All Correct Drawing of structures of all compounds AND Correct justification for all structures	6
Correct Drawing for most of structures of the compounds AND Correct justification for most structures	4 - 5
Correct drawing some of the structure of the compounds AND Provides justification for some of the structures	3
Identifies some characteristics (functional groups) of some structures	2
Provides some relevant information	1

	Structural formula	*Justification*
A	 2-methylpropan-1-ol	Compound *A* is a primary alcohol as oxidation of compound *A* produces an acid, compound *C*. The branched structure is indicated by the formation of the tertiary alcohol, compound *E*.
B	 1-chloro-2-methylpropane	Compound *B* is a chloroalkane formed by the replacement of OH with Cl in compound *A*.
C	 2-methylpropanoic acid	Compound *C* is the acid produced by the oxidation of compound *A*. This is confirmed by the production of CO_2 when reacted with carbonate ion.

D	 2-methylpropene	Compound *D* is the alkene produced from compound *A* through the dehydration reaction, which removes the OH and another H atom to form the double bond.
E	 2-methylpropan-2-ol	Compound *E* is a tertiary alcohol as compound *E* is not oxidised with strong oxidants.
F	 sodium 2-methylpropanoate	Compound *F* is the sodium salt of the acid.

Exam Choice 28

Describe the relationship between the structure of soaps and their cleaning action.

Include an appropriate diagram with your answer. **3**

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Examiners Comments:

Generally well done some student also included drawings of Micelles and how grease was removed from a surface with a sequence of diagrams.

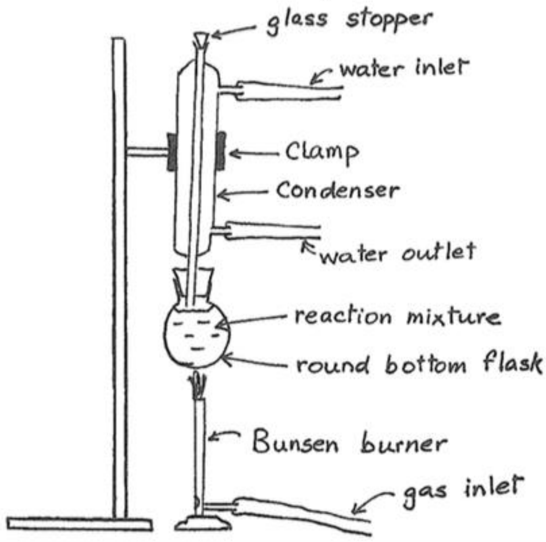
Marking Criteria	Marks
• Describes the structure of soap and detergents and relates this to their cleaning action using appropriate scientific language.	3
• Outlines the structure of soap and/or detergents and relates this to their cleaning action.	2
• Response contains one correct, relevant statement.	1

Soaps and detergents are long-chain species with a non-polar, hydrophobic 'tail' and a hydrophilic 'head'. For soaps the hydrophilic 'head' is the carboxylate ion, whereas for detergents it can be anionic (benzenesulfonate), cationic (quaternary ammonium salts) or non-ionic (polyether). The structure of these species can be represented as:

Oil and water are not miscible. When soap or detergent is added to a mixture of oil and water the hydrophobic end dissolves in the oil droplets. The hydrophilic end dissolves in the water. When the mixture is agitated a spherical particle called a micelle is formed in which the oil droplet is surrounded by soap/detergent particles, which are in turn surrounded by water molecules. In this way the soap/detergent acts as an emulsifying agent and an emulsion of oil and water is formed. This allows the oil to be washed away and accounts for the cleaning action of soaps and detergents.

Question 29 (6 marks)

(a) In a student's report of the above experiment , the following diagram was included. As shown, the apparatus is both ***dangerous*** and ***inefficient***.
List THREE aspects for this set-up which represent bad techniques and give reasons for your choices. **6**



3 sound issues of bad technique described with reasons	5- 6
2 issues described with some reasons	3-4
1 issue mentioned with some reason	1-2

Sample Answer

Round bottom flask is not clamped. It could drop from the condenser and break spilling the hot reactants which could include concentrated acids or base.

The water inlet and outlet tubes are reversed. The condenser would not have a correct flow of water to maximise the condensation and some gases may escape as the condenser is not working efficiently.

The glass stopper at the top of the condenser could allow for pressure to build up in the apparatus as gases were not escaping and this could result in the equipment blowing up and shattering with chemicals and glass being exploded across the area and injuring anyone nearby.

The bunsen burner is not the best way to heat volatile alcohols a water bath should be used to prevent flammable material (alcohol) in contact with a naked flame.

Question 30

(a)

Criteria	Marks
• Identifies the solution H_2CO_3/HCO_3^- as a buffer • States that the addition of a small amount of acid or base causes the equilibrium position to shift so that the pH remains the same	2
• Identifies the solution H_2CO_3/HCO_3^- as a buffer	1

Sample answer:

An equimolar solution of H_2CO_3/HCO_3^- is a buffer. This is a solution consisting of a weak acid and its conjugate base.

If a small amount of acid such as HCl is added to this buffer then the equilibrium will shift to the left as the increase in hydrogen ions will cause the reaction to shift in such a way as to counteract the change and the pH will remain constant.

If a small amount of base such as NaOH is added to this buffer then the equilibrium will shift to the right as the increase in hydroxide will cause the reaction to shift in such a way as to counteract the change and the pH will remain constant.

Examiners Comments:

Students generally did not name and describe the buffer in the equation and that a buffer consists of a weak acid and its conjugate base.

There was poor understanding that the pH will remain constant with a buffer.

(b) Identify a natural buffer and describe its importance in a natural system (2 marks)

	Mark
Correct identification of buffer in natural system with description of importance	2
Identification Or importance	1

Examiners Comments:

Students generally failed to describe importance of the buffer.

Question 31 (3 marks)

Criteria	Marks
• Correctly concludes solutions A and B must be basic, and concludes, based on correct reasoning, that solution C may be in the range basic to acidic and assesses that the conclusion may be or may not be correct, using the colour changes of the indicators and their pH ranges.	3
• Correctly concludes solutions A and B must be basic, and concludes, based on correct reasoning, that solution C may be in the range basic to acidic	2
• Correctly concludes solutions A or B must be basic **or** Makes a correct assessment without any explanation	1

The student's assessment of solutions A and B are correct because both turned thymol blue to a blue colour. This indicates a pH greater than 8.0, which is basic.

The student's assessment of solutions C may be incorrect. The solution turned thymol blue yellow indicating a pH of less than 8.0. This could be basic if the pH is between 7 and 8, acidic if the pH is less than 7, or neutral if the pH is 7.

Question 32 (7 marks)

(a)

Criteria	Marks
• Calculates the moles of sodium hydroxide which reacted with the excess HCl	1

Sample answer:

Moles of NaOH which react with excess HCl

n=C x V

n= 1.0 x 0.01715

n= 0.01715 moles of NaOH

(b)

Criteria	Marks
• Calculates the moles of HCl added to the chalk sample • Determines the actual number of moles of HCl which reacted with the $CaCO_3$ • Uses a balanced equation to determine the molar ratio for each reaction • Calculates the number of moles of $CaCO_3$ in the chalk sample	4
• Three of the above correct	3
• Two of the above correct	2
• One of the above correct	1

Sample answer:

Moles of HCl added to the chalk

n= C x V

n= 1.00 x 0.100

n= 0.10

Since NaOH reacts with HCl in a 1: 1 molar ratio number of moles of excess HCl = 0.01715

Therefore number of moles of HCl which reacted with $CaCO_3$ = 0.10 - 0.01715 = 0.08285

$$CaCO_{3(aq)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$$

Since $CaCO_3$ reacts with HCl in a 1:2 molar ratio number of moles of in the chalk sample is

0.08285/2 = 0.041425 moles

(c)

Criteria	Marks
• Calculates molar mass of $CaCO_3$ • Calculates mass of $CaCO_3$ in chalk sample	2
• Calculates molar mass of $CaCO_3$	1

Sample answer
Molar mass of $CaCO_3$ = 100.09g
Mass of $CaCO_3$ in chalk sample
m = n x M

m = 0.041425 x 100.09 = 4.14 g

Question 33 (6 marks)

(a)

Criteria	Marks
• Correctly calculates the number of moles of water formed, the heat change q and the heat of neutralisation	3
• Correctly calculates the number of moles of water formed and the heat change q	2
• Correctly calculates the number of moles of water formed.	1

(a) $H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$

1 mole of sulfuric acid (a diprotic acid) reacts with 2 moles of alkali to form 2 moles of water.

$2H^+(aq) + 2OH^-(aq) \rightarrow 2H_2O(l)$

moles of water formed = moles of sodium hydroxide

$$= \frac{120}{1000} \times 0.500$$

$$= 0.0600 \text{ mol}$$

heat change $(q) = mc\Delta T$

$$= \frac{(120 + 60)}{1000} \times 4.18 \times 10^3 \times (26.3 - 24.2)$$

$$= 0.8 \times 4.18 \times 2.1 = 1.58 \text{ kJ}$$

$$\therefore \Delta H = \frac{-q}{n(\text{water})} = \frac{-1.58 \text{ kJ}}{0.06 \text{ mol}} = -26.3 \text{ kJ mol}^{-1} \text{ (exothermic)}$$

(b)

Criteria	Marks
• Assesses the reliability of the experiment	3
• Describes the reliability of the experiment	2
• States the reliability of the experiment	1

The experiment is unreliable because it was not repeated. The experiment was only performed once. Other factors that can affect reliability are:

- ➢ Stirring the solution to distribute the heat evenly throughout the solution
- ➢ Same insulation used repeated trials
- ➢ Also comparing results with other groups using the same equipment.

Question 34 (8 marks)

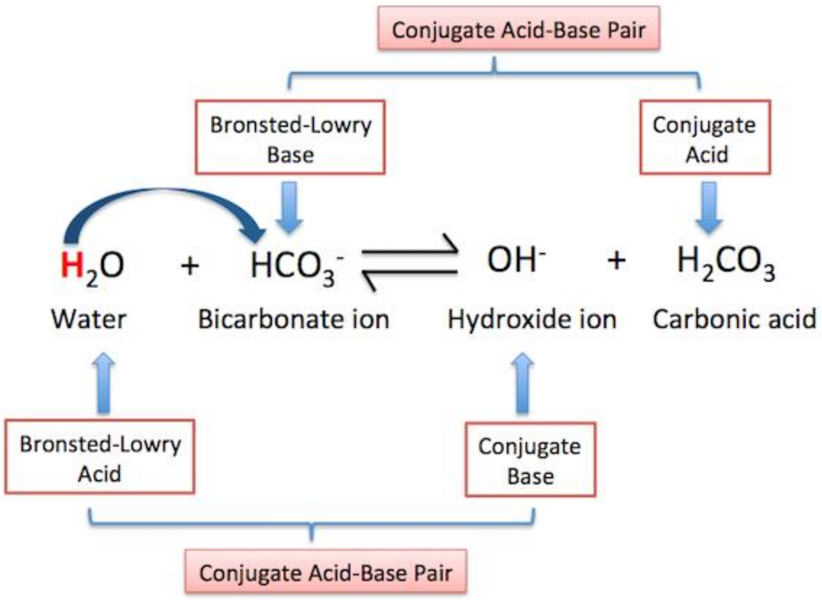
Criteria	Marks
• Contribution of the Arrhenius and Bronsted and Lowry Theories with balanced chemical equations for each Theory • Two limitations for one of the Theories **AND** a limitation for the other Theory explained	7-8
• Contribution of the Arrhenius and Bronsted and Lowry Theories with balanced chemical equations for each Theory • Two limitations for one of the Theories **OR** a limitation for the other Theory explained	5-6
• Contribution of the Arrhenius and Bronsted and Lowry Theories • Two limitations for one of the Theories or a limitation for the other Theory explained **OR** • Contribution of the Arrhenius and Bronsted and Lowry Theories with balanced chemical equations for each Theory	3-4
• A description of both of the Theories **OR** • A balanced chemical equation for both of the Theories **OR** • A limitation of both of the Theories	2
• A description of one of the Theories **OR** • A balanced chemical equation for one of the Theories **OR** • A limitation of one of the Theories	1

Arrhenius defined acids as substances that produce hydrogen ions in solution
e.g $HCl \rightarrow H^+ + Cl^-$

Arrhenius defined bases as substances that produce hydroxide ions in solution

e.g $NaOH \rightarrow Na^+ + OH^-$

Bronsted and Lowry defined acids as proton donors and acids as proton acceptors



Limitations of the Arrhenius Theory

I. It only accounts for those substances which already have H^+ or OH^- in their structures e.g. HCl and NaOH.
II. It only applies to aqueous solutions and not to other solvent systems.
III. It does not account for the behaviour of amphiprotic species. Species that can donate a proton or accept a proton

Limitations of the Bronsted and Lowry Theory

I. It did not explain the acids and bases that did not have hydrogen e.g. BF_3 and $AlCl_3$
II. It fails to explain reactions between acidic oxides e.g. SO_3 and basic oxides e.g. CaO

Question 35 (6 marks)

(a)

Marking Guidelines	Marks
• Identifies a suitable incorrect rinsing procedure and explains how it would give rise to the incorrect value by referring to moles.	3
• Identifies a suitable incorrect rinsing procedure and outlines its effect on the calculated concentration.	2
• Identifies an incorrect rinsing procedure.	1

If Group B had only rinsed their burette with water then the solution it delivered would have been more dilute than expected, and thus a greater volume of base would be required to titrate the acid than would otherwise have been the case. This means that n(base calculated) > n(base real). This means that n(acid calculated) > n(acid real), and thus the calculated concentration will also be higher than the true value.

(b)

Criteria	Marks
• Explains why titrations do not indicate acid strength **and** why the pH of equimolar solutions does	3
• Explains why titrations do not indicate acid strength **OR** why the pH of equimolar solutions does	2
• Identifies one reason why titrations do not indicate acid strength or makes one correct statement about concentration and pH	1

Equimolar HCl and ethanoic acid will give the same result in a titration because, titration reactions provide data from which concentration is calculated, not acid strength. This is because these reactions go to completion. On the other hand, the relative pH of equimolar (monoprotic) solutions does reveal the relative strength. HCl will have a pH equal to the pH calculated on the basis of complete ionisation. The weak acid ethanoic acid, does not ionise fully so the $[H^+]$ is lower than for HCl. This gives a pH value higher than that of HCl.