LMC Lachlan Macquarie College

Chemistry

Trial Higher School Certificate Examination

2019

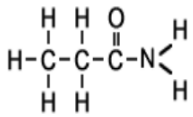
General Instructions	• Reading Time – 5 minutes • Working Time – 3 hours • Write using black pen • Draw diagrams using pencil • NESA approved calculators may be used
Total Marks	**Section I – 20 marks (pages 2 – 8)** • Attempt questions 1 – 20 • Allow about 35 minutes for this section **Section II – 80 marks (pages 9 – 18)** • Attempt questions 21 – 35 • Allow about 2 hours and 35 minutes for this section

Section I – Multiple Choice

20 marks (1 mark each)

Please answer on the answer sheet provided.

1. The correct name of the following organic compound is



(a) Propanamide
(b) Propanamine
(c) Propanol
(d) Propanoic acid

2. Which of the following is not true about low density polyethylene.

(a) Tough
(b) Hard
(c) Poor conductor of electricity
(d) Highly branched structure

3. 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

4. The table gives heat of combustion kJ g^{-1} for a number of different fuels.

Fuel	Heat of combustion kJ g^{-1}
Butanol	30.8
Pentanol	36.5
Hexanol	41.2
Petrol (Octane)	47.8

The heat of combustion in kJ mol^{-1} for one of the fuels was calculated as 3218 kJ mol^{-1}. What was the fuel?

(a) Hexanol
(b) Octane
(c) Butanol
(d) Pentanol

5. Soaps and detergents are classified as emulsifiers because

   (a) They reduce the hardness of water
   (b) They reduce the surface tension of water
   (c) They are polar
   (d) They are biodegradable.

6. Four students analysed a sample of fertiliser to determine its percentage of sulfate.

   Each student:

   - Weighed an amount of fertiliser
   - dissolved this amount in 100 mL of water;
   - added aqueous barium nitrate;
   - filtered, dried and weighed the barium sulfate precipitate.

   Their results and calculations are shown in the table.

Student	Mass of fertiliser used (g)	Mass of $BaSO_4$ weighed (g)	Percentage of sulfate in fertiliser(%)
A	11.6	19.5	69.2
B	10.4	16.9	66.9
C	10.268	22.612	90.6
D	11.1	18.2	67.5

The percentage of sulfate calculated by Student *C* was significantly higher than that of the other students. Which is the most likely reason for this?

   (a) Student *C* did not dry the sample for long enough.
   (b) Student *C* added more $Ba(NO_3)_2$ solution than the other students.
   (c) Student *C* used a balance capable of measuring weight to more decimal places.
   (d) Student *C* waited longer than the other students for the $Ba(NO_3)_2$ to react completely with the sulfate.

7. Silver chloride dissolve in ammonia solution due to the formation of

   (a) $Ag(NH_3)^{2+}(aq)$
   (b) $Ag(NH_3)^{2+}(aq) + Cl^-(aq)$
   (c) $[Ag(NH_3)_4](l)$
   (d) $Ag(NH_2)_3(aq) + Cl^-(aq)$

8. The number of peaks that would be expected from a ^{1}H NMR spectrum for propanone (CH_3COCH_3) is

   (a) 2
   (b) 1
   (c) 6
   (d) 3

9. 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

10. Which of the following statements is incorrect about the collision theory of chemical reactions?

   (a) It considers reacting molecules or atoms to be inflexible, rigid structures.
   (b) The number of successful collisions determines the rate of reaction
   (c) Product molecules are produced only when colliding reactant molecules or atoms possess the threshold energy.
   (d) Reactant molecules or atoms should collide with sufficient threshold energy and correct orientation for the collision to successfully produce product molecules.

11. Consider the following equation:

   $2SO_2\ (g) + O_2\ (g) \rightarrow 2SO_3\ (g)$ D H = -189.4kJ

   If the system was to experience a change in pressure and temperature select which changes in the table below would result in this system favouring the right.

	Change in temperature	Change in pressure
(a)	Decrease	Decrease
(b)	Increase	Increase
(c)	Decrease	Increase
(d)	Increase	decrease

12. 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) $2[SO_3] / 2\,[SO_2]\,[O_2]$

13. Choose the most correct statement to describe what occurs when a solution of sodium hydroxide is added to a saturated solution of $Mg(OH)_2$
(a) The solubility of $Mg(OH)_2$ will be determined by the equilibrium constant K_{sp}
(b) The solubility of $Mg(OH)_2$ will be increased
(c) The total amount of Mg^{2+} will increase
(d) The total amount of OH^- will be unchanged because it is saturated already.

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

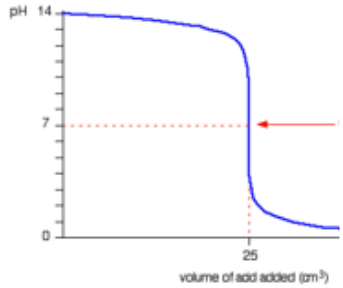
Indicator	pK_{ind}	pH range	colour at lower pH	colour at higher pH
bromophenol blue	4.0	3.0 - 4.6	yellow	blue
methyl red	5.1	4.2 - 6.3	red	yellow
phenolphthalein	9.3	8.3 - 10.0	colourless	red

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

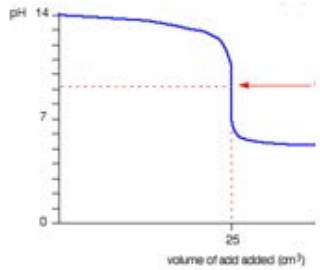
	Bromophenol blue	**Methyl red**	**Phenolphthalein**
(a)	yellow	red	colourless
(b)	yellow	yellow	colourless
(c)	green	orange	colourless
(d)	green	red	colourless

15. Titration curves are obtained when an acid and base are reacted with a pH probe inserted into one of the solutions. Refer to the graphs below, X and Y to answer which option a, b, c or d correctly identifies the acids and bases involved in this titration and also correctly identifies what the red arrow is indicating.

X



Y



	Graph X	Graph Y	Red arrow
(a)	Strong base/Strong acid	Strong base/Strong acid	Equivalence point
(b)	Strong base/ Weak acid	Strong base/ Weak acid	Equivalence point
(c)	Weak base/Weak acid	Weak base/weak acid	Equivalence point
(d)	Strong base/Strong acid	Strong base/Weak acid	Equivalence point

16. Which option below correctly identifies how the glassware should be prepared when titrating standard 0.1038 Mol.L^{-1} solution of HCl with an unknown concentration of ammonia. Ammonia will be the titrant and HCl will be delivered as 25.00mL aliquots.

	Burette	Pipette	Conical flask
(a)	Washed with Distilled water only	Washed with Distilled water only	Washed with Distilled water only
(b)	Washed with Distilled water then the ammonia solution	Washed with Distilled water then the hydrochloric acid solution	Washed with Distilled water then the hydrochloric acid solution
(c)	Washed with Distilled water then the hydrochloric acid solution	Washed with Distilled water then the ammonia solution	Washed with Distilled water then the ammonia solution
(d)	Washed with Distilled water then the ammonia solution	Washed with Distilled water then the hydrochloric acid solution	Washed with Distilled water only

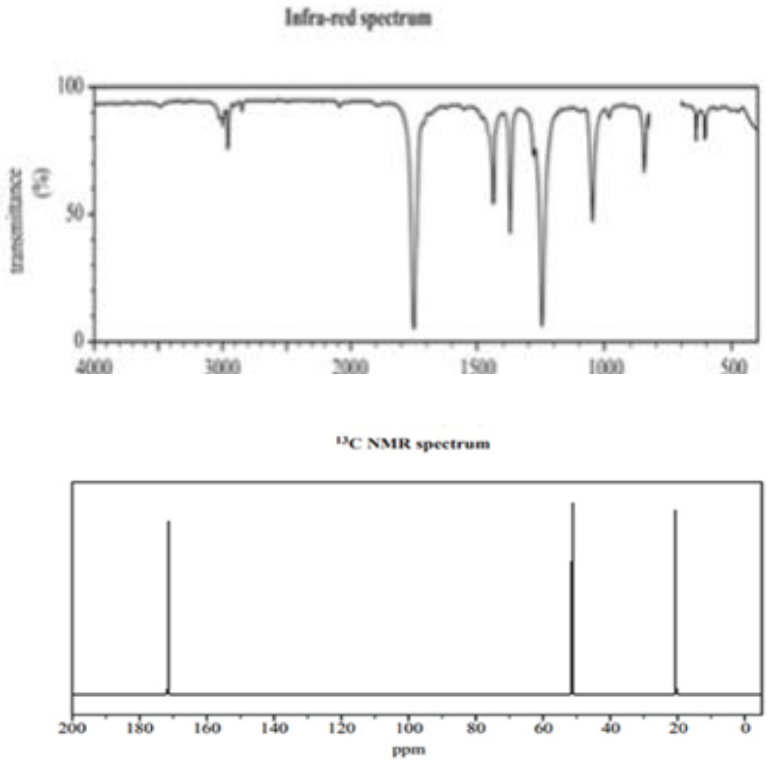
17. What is the pH of a 0.05 m0l.L^{-1} solution of sodium hydroxide?

(a) 2.0
(b) 2.3
(c) 12.7
(d) 12

18. A 20.00mL solution of 0.1000 mol.L^{-1} hydrochloric acid is diluted to 200.00mL. Identify what the pH change would be from the options a, b, c or d.

	Original pH	Final pH
(a)	1	2
(b)	2	1
(c)	0.1	0.01
(d)	0.01	0.1

19. The following two spectra were obtained for a pure organic substance, Compound W.



The formula of Compound W that is consistent with the spectra above is:

(a) $CH_2(OH)CH_2CH_2OH$
(b) CH_3CH_2COOH
(c) CH_3COOCH_3
(d) CH_3COCH_3

20. Petrol is a mixture of hydrocarbon molecules varying in size from six to ten carbon atoms. Forensic investigators suspect that traces of a substance found at a suspicious fire could be petrol that was used to start the fire. Which one of the following techniques could best be used to identify the substance?

(a) NMR spectroscopy
(b) UV-Visible spectroscopy
(c) atomic absorption spectroscopy
(d) gas chromatography followed by mass spectroscopy.

End of Section I

Examination continued on next page

Section II – Written responses

80 marks (2 – 9 marks)

Please answer in the spaces provided

Question 21 (7 marks)

In a gravimetric analysis of the purity of an ammonium sulfate fertilizer, a 5.47g sample was dissolved in dilute hydrochloric acid and filtered to remove insoluble solids.

An excess of barium chloride solution was added, and the precipitate collected by filtration. The dried residue had a mass of 9.15g

(a) Write a balanced equation for the precipitation reaction. **(2)**

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(b) Calculate the % by mass of ammonium sulfate in the fertilizer. **(2)**

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(c) Describe one of the difficulties this analysis may present, and suggest how to overcome it **(3)**

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Question 22 (6 marks)

(a) Outline the main stages of the techniques known as Atomic Absorption Spectroscopy **(2)**

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(b) Discuss why AAS is so widely used in the analysis of some pollutants and in the testing of trace elements. **(2)**

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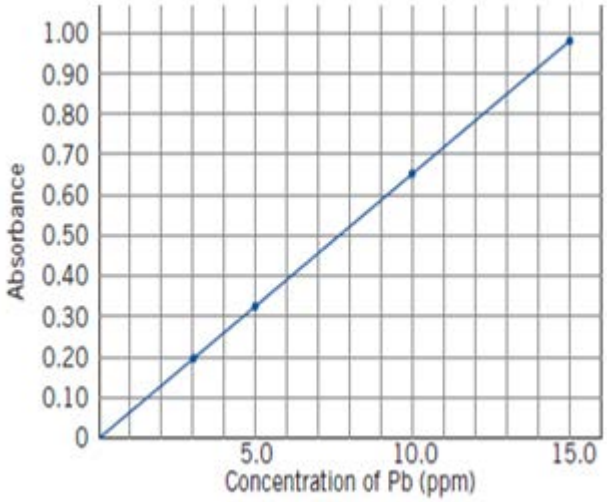
(c) A roadside soil sample was analysed to determine its lead concentration. A 2.00g sample was subject to acid digestion and made up to a 100ml of solution. This was then analysed using an atomic absorption spectrometer, and the absorbance of light at 217nm was found to be 0.360. Use the calibration curve to calculate the lead level in the soil in ppm. **(2)**



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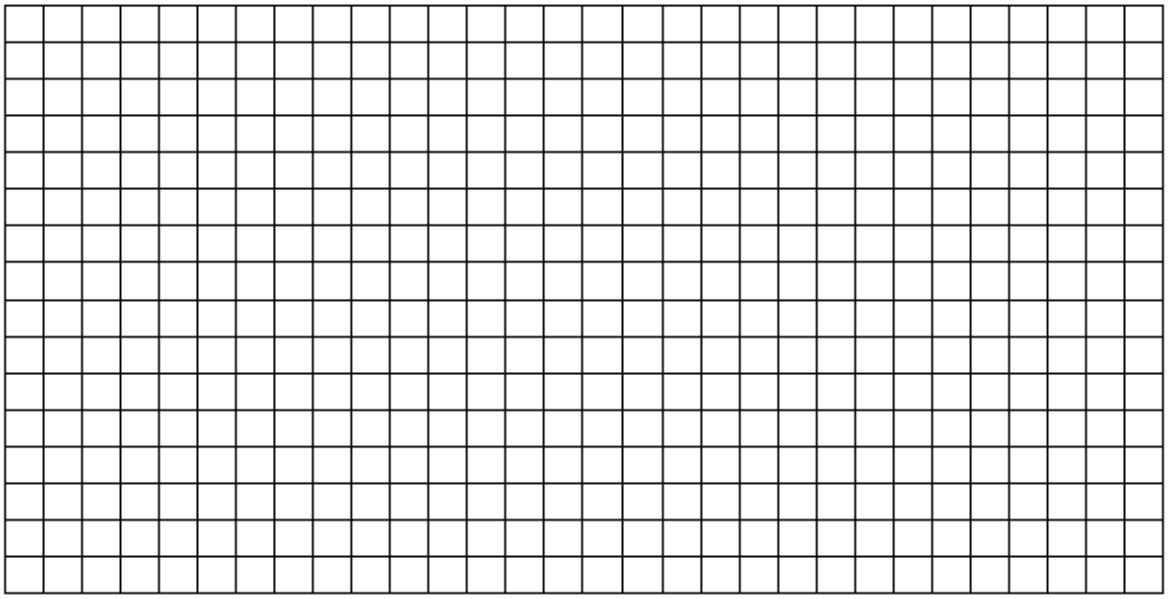
Question 23 (7 marks)

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 (^{0}C)
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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(c) Kevin plotted a similar graph for molar mass and boiling point of Alcohols.
Predict and explain the difference in the boiling point of Alcohols and Organic acids. **(3)**

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Question 24 (9 marks)

During your studies you have investigated reversible reactions. Describe how you conducted a safe, valid and reliable procedure to demonstrate the dynamic nature and reversibility of this reaction.

Question 25 (3 marks)

The value of K_{eq} for the reaction below is 1.00×10^{-5} at 25.00°C.

$$NH_{3\,(aq)} + H2O_{\,(l)} \rightleftharpoons NH4^{+}{}_{(aq)} + OH^{-}{}_{(aq)}$$

Calculate the pH for the resulting solution when 100.00 mL of 5.00 mol.L^{-1} ammonia and 100.00 mL of 5.00 mol.L^{-1} ammonium chloride are mixed.

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Question 26 (9 marks)

A student placed 3 granules of solid Calcium metal into a small beaker with 50.00mL of 1.00 mol.L^{-1} Hydrochloric acid and noticed bubbling and the calcium disappeared. However when the same reaction was repeated with 50.00mL of 1.00 mol.L^{-1} Sulfuric acid they were surprised to observe that after a couple of minutes the bubbling stopped and the calcium, though looking a little paler and more powdery, remained at the bottom of the beaker.

(a) Using your knowledge of how acids react with metals and solubility rules explain using relevant equations why the student observed these 2 different situations. **(3)**

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(b) Using your Le Chatelier's principle explain what would happen to the value of the equilibrium position and constant and if the student continued adding excess sulfuric acid to the beaker with sulphuric acid and calcium at the same temperature. **(3)**

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Question 27 (3 marks)

How did Aboriginal and Torres Strait Islander Peoples use their knowledge of solubility equilibria to remove toxins in cycad fruit?

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Question 28 (6 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:

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

$K_{eq} = 3.6$ at 1173K

Given the concentrations recorded in the table: Explain whether the reaction is at equilibrium or favours the reactants or products. **(3)**

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

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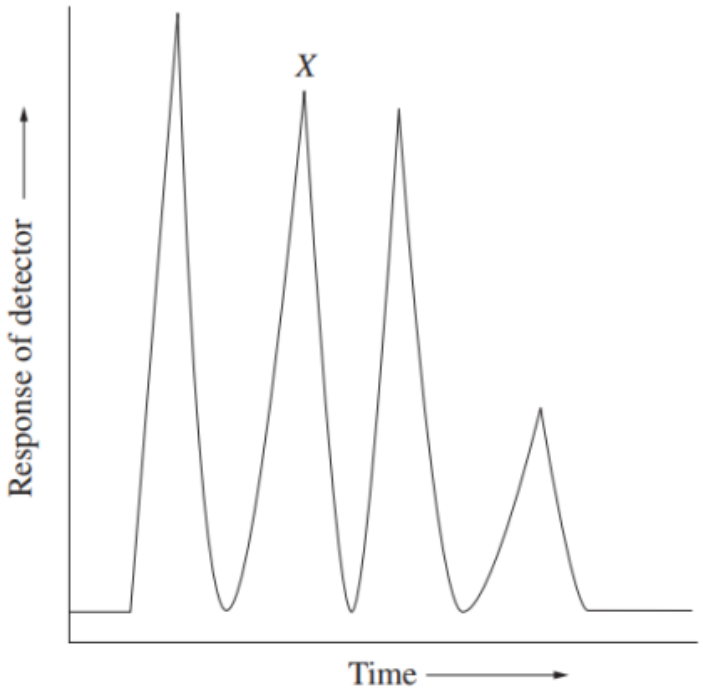
Question 29 (7 marks)

Gas Chromatography is one of the technologies used to analyse organic compounds. An analysis was performed on a mixture of 1-hexanol, 1- octanol, 1-heptanol and 1-pentanol. Chemists identified the peak X as 1-heptanol.

Compare how TWO other technologies you have studied have enhanced our understanding of the structure of a range of organic compounds.



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Question 30 (4 marks)

During your study of Chemistry you have used models to enhance your understanding. Discuss how a model you have used improved your understanding of a concept you have learnt.

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Question 31 (4 marks)

A student measured the pH of three solutions X, Y, Z with a pH probe. They stirred the solution constantly and the measurements were all recorded at 25.0°C. Unfortunately, they did not label their beakers but their teacher said they should be able to identify from the pH recorded. The measurements were 6.9; 8.7; 5.3

The solutions were sodium chloride, ammonium nitrate and sodium acetate. Identify what each solution X, Y and Z are most likely to be and explain your choices.

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Question 32 (4 marks)

A 0.1045 mol.L^{-1} solution of sodium hydroxide was used to determine the concentration of an unknown solution of acetic acid. The acetic acid was prepared by mixing 10.00mL Cornwall's Vinegar with 90.00mL of distilled water.

Using the results recorded below calculate the concentration of acetic acid in the bottle of Vinegar when 25.00 mL pipettes were used to deliver the vinegar into the conical flask.

Titre	Volume of Sodium Hydroxide (mL)
1	24.99
2	25.10
3	28.50
4	24.96

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Question 33 (4 marks)

Describe the importance of buffers in natural systems.

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Question 34 (8 marks)

(a) During your studies you explored how our definitions and models of acids and bases changed over time. How did you decide your references were valid and reliable? **(2)**

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(b) With reference to Arrhenius, Bronsted-Lowry and one other scientist(s) of your choice explain the limitations of their models. **(6)**

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Question 35 (4 marks)

Using a labelled diagram, explain why refluxing is used to produce an ester.

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End of examination

Acknowledgements:
Mrs Katherine Barbeler (Head Teacher Science – Gosford HS)
Mrs Reena Makkar (Head Teacher Science – Blacktown Girls HS)

LMC Chemistry Trial Marking guidelines

Section I

Question	Answer
1	A
2	B
3	A
4	D
5	B
6	A
7	B (most correct)
8	B
9	D
10	A
11	C
12	B
13	B
14	B
15	D
16	D
17	C
18	A
19	C
20	A

Section II

Question 21

21 A)

Marks	**Marks**
$(NH_4)_2SO_4(aq)$+ BaCl2(aq) $BaSO_4(s)$+ $2NH_4Cl(aq)$ WITH STATES	2
As above slight error or no states	1

B)

Marks	**Marks**
moles of $BaSO_4$: n = m/ MM= 233.4g = 9.15/233.4 = 0.03920 mol ∴ moles of $(NH_4)_2SO_4$ = 0.03920 mol (ratio 1:1) mass of $(NH_4)_2SO_4$: m = n x MM MM = 132.1g = 0.03920 x 132.1 = 5.178 g ∴ % sulfate in sample = 5.178 x 100 = 94.7%	2
As above but calculator error	1

C)

Marks	**Marks**
The precipitate of barium sulfate is very fine grained and often passes through a normal filter Or not all the sulfate precipitates add excess	2
Identifies difficulties or improvements	1

Question 22

a) Marking Criteria	**Marks**
Explains the AAS process and links it to electron movement	2
Identifies some features of AAS	1

Electrons in an element absorb electromagnetic radiation and move to a higher energy level. As the electron falls back to a lower energy level it emits radiation of a particular frequency thus identifying the element.

a) Marking Criteria	**Marks**
Identifies the use of AAS in detecting low concentration (ppm and ppb)	2
Identifies AAS being used for detecting low concentration	1

AAS can detect low concentration (ppm and ppb) of elements, therefore it is useful in detection of trace elements.

Marking Criteria	Marks
Correctly calculates the concentration of lead with units	2
Correctly calculates the concentration of lead without units.	1

a. Concentration of Pb in solution = 5.5 mg kg^{-1}
Mass of Pb in solution = 5.5 x 0.1 = 0.55mg
Concentration of Pb in soil = 0.55/0.002

= 275 ppm

Question 23

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

b)

Marking criteria	Marks
Correct value from the graph	1

c)

Marking criteria	Marks
Predicts that acids have higher boiling point than alcohols. Explains the variation in boiling points between carboxylic acid and alcohols in terms of the strength of the intra-molecular forces involved due to different functional groups present	3
Predicts that acids have higher boiling points Outlines the variation	2
Identifies acids have higher boiling points OR identifies the reason for variation	1

Question 24

	Marks
Relevant example with correct balanced equation, including states and equilibrium arrow. Procedure is detailed with equipment and sensible quantities Risks are addressed- fume cupboard if needed, safety glasses, disposal if relevant Variables: independent and dependent identified, change in colour clearly linked to direction of reaction Reliability addressed- repetition of experiment LeChatleier's principle is used to explain the shifts in direction and student links these changes to the dynamic nature of equilibrium	9
As above but response is less logical and may not have included states on the equation	8
As above but explanation of the changes is not clearly linked to LCP, equation may not have states	7
As above but changes in direction are identified only- not explained, equation may not have states	6
As above but LCP is not used, procedure is lacking quantities or maybe equipment not specifically named, equation may not have states	5
Procedure lacks detail, equation incorrect or missing, identifies changes in direction only	4
Procedure lacks detail, identifies changes in direction only	3
Procedure or description of results	2
Some basic understanding demonstrated	1

Question 25

Marks	
K eq= $[NH_4^+] [OH^-] / [NH_3]$ $[OH^-] = 1.00 \times 10^{-5}$ pOH= -log $1.00 \times 10^{-5} = 5$ pH = 14-5 = 9	3
One step missing or calculator error or calculation correct but does not include K equation	2
One correct step	1

Question 26

Marks	
Writes the correct balanced equations with states Identifies that with sulfuric acid the solid calcium sulfate forms and this stops the bubbling Calcium chloride is soluble so the reaction continues Identifies the gas as hydrogen	3
As above but equation lacks states Relationship between the solid calcium sulfate and the stopping of the gas bubbles less apparent	2
No equations or incorrect equations	1
Marks	
Ksp expression written correctly for Calcium sulfate AND Students explains how the increase sulfate concentration changes this value from a mathematical perspective	3
Ksp expression written correctly for Calcium sulfate AND Students identifies the increase sulfate concentration changes this value from a mathematical perspective	2
Ksp expression written correctly for Calcium sulfate OR Students identifies the increase sulfate concentration changes this value from a mathematical perspective	1

Question 27

Marks	
Identify the toxin, describe the process used to remove the toxin and relate the effect of the toxin on the food	3
As above but description lacks detail	2
Any correct information	1

Question 28

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 29

Marking Criteria	Marks
Identifies two technologies Explains the process for both the technologies Identifies two advantages and two disadvantages for each technology	6-7
Identifies two technologies Explains the process for both the technologies Identifies an advantage OR a disadvantage for both technologies OR Identifies two technologies Explains the process for both the technologies Identifies an advantage and a disadvantage for a technology	4-5
Identifies two technologies AND Explains the process for a technology Identifies an advantage and a disadvantage	2-3
Identifies a technology	1

Question 30

Marks	
Specific example of model AND Benefits of model AND Limitations of model	4
Specific example of model AND Benefit of model AND Limitation of model	3
Specific example of model Benefit of model OR Limitation of model	2
Specific example of model OR Benefit of model OR Limitation of model	1

Question 31

Marks	
Correctly identifies sodium chloride as neutral, Ammonium nitrate as acidic, Sodium acetate Writes equations and shows how the ions react with water thus altering pH	4
As above but does not use equations to show how pH changes	3
At least 2 salts correctly matched to pH AND shows some understanding of how these ions affect pH or shows through understanding but has mismatched the slats to their pH	2
Identifies 1 salt or all salts but no explanation	1

Question 32

Marks	
Writes fully balanced chemical equation with states Averages titre but ignores #3 Calculates moles of sodium hydroxide and relates to moles of acetic acid Calculates concentration of acetic acid used or uses C1V1=C2V2 correctly Dilutes concentration by 10 due to 1 in 10 dilution	4
Writes fully balanced chemical equation with states Averages titre but includes #3 Calculates moles of sodium hydroxide and relates to moles of acetic acid Calculates concentration of acetic acid used or uses C1V1=C2V2 correctly Dilutes concentration by 10 due to 1 in 10 dilution	3
As above but doesn't do the 1 in 10 dilution and equation may be lacking states	2
1 correct step	1

Question 33

Marks	
Identifies a natural buffer, writes a balanced chemical equation, includes states Describes what a buffer does Relates the function of their buffer to the equation (uses B-L) theory Describes how their example minimises changes in pH of the natural system	4
As above but description of the function of their buffer lacks detail	3
Demonstrates some understanding of buffers and provides a specific example, may not include an equation.	2
Demonstrates some understanding of buffers OR provides a specific example, may not include an equation.	1

Question 34

Marks	
References written by qualified/reputable authors, no bias, recent and information is consistent across many sources	2
One of the above lacking	1

Marks	
Arrhenius model described correctly B-L model described correctly 1 other described correctly Includes specific examples of what would and would not be included in each model for acids and bases	6
As above but answer is not logical in its development	5
Arrhenius model described correctly B-L model described correctly 1 other described correctly	4
Only 2 models described correctly	3
Only 1 model described correctly	2
1 correct statement	1

Question 35

Marking criteria	Marks
Correct structural formula for acid, alcohol and ester	2
Correct structural formula for at least two chemicals	1

Marking Criteria	Marks
Explains correctly the reasons for refluxing AND Includes a correctly labelled diagram	4
Describes a reason for refluxing AND Includes a correctly labelled diagram	3
Outlines a reason for refluxing AND Includes a substantially correct diagram	2
States a reason for refluxing AND Includes a diagram recognisable as reflux apparatus	1