CRANBROOK SCHOOL

1	2	5

Centre Number

Student Number

2019 | TRIAL EXAMINATION

Chemistry

General Instructions

- Assessment Task 4 – Weighting 30%
- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A formulae sheet, data sheet and Periodic Table are provided at the back of this paper
- For questions in Section II, show all relevant working in questions involving calculations

Total marks: 100

Section I – 20 marks (pages 2-8)

- Attempt Questions 1-20
- Allow about 35 minutes for this section

Section II – 80 marks (pages 11–25)

- Attempt Questions 21-33
- Allow about 2 hours and 25 minutes for this section

Section I

20 marks
Attempt Questions 1-20
Allow about 35 minutes for this section

Use the Multiple-choice answer sheet for Questions 1-20

1. What is the final substance you rinse a conical flask with before commencing titration?

A) the solution in the burette

B) the solution to be added by the pipette

C) distilled water, with the flask being dried before use in a drying oven

D) distilled water and left wet

2. Which of the following substances is NOT involved in the fermentation process?

A) carbon dioxide

B) ethanol

C) glucose

D) oxygen

3. The seeds of the cycad plant contain a toxin called cycasin. Indigenous Australians use techniques to detoxify these seeds to allow them 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.

What property of the cycasin toxin does this method use?

A) The toxin is soluble in water.

B) The toxin is insoluble in water

C) The density of the toxin is higher than water.

D) The toxin is able to react with water.

4. What is the conjugate acid of HS^-?

A) H^+

B) S^{2-}

C) H_2S

D) $HS(OH)^{2-}$

5. How many isomers can exist for a compound with the molecular formula $C_2H_2Cl_2$?

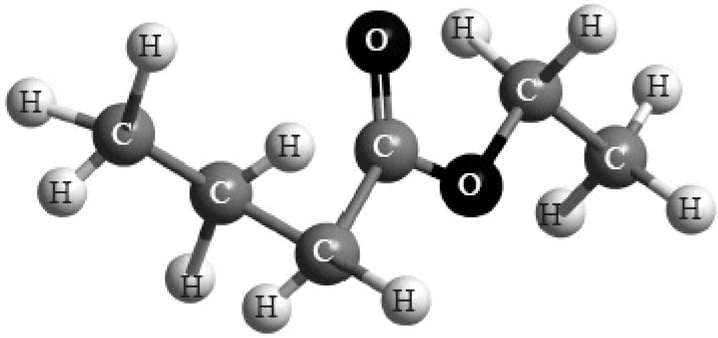
A) 1

B) 2

C) 3

D) 4

6. Which reactants could be used to form the compound below?



A) Butanoic acid and ethanol

B) Propanoic acid and ethanol

C) Ethanoic acid and propan-1-ol

D) Ethanoic acid and butan-1-ol

7. Which of the following observations can be explained by the Bronsted-Lowry theory of acids but not the Arrhenius theory?

A) A solution of hydrochloric acid is a good conductor of electricity.

B) Magnesium will displace hydrogen from a solution of sulfuric acid.

C) Hydrogen chloride and ammonia gas react to produce solid ammonium chloride.

D) When passed through water, carbon dioxide gas decreases the pH of the water.

8. Polyethene (polyethylene) is an extremely important polymer, available in two general forms-high density polyethene (HDPE) and low density polyethene (LDPE). Which of the following statements about polyethene is correct?

A) HDPE is branched and has a lower melting point than LDPE.

B) HDPE unbranched and has a lower melting point than LDPE.

C) LDPE is branched and has a lower melting point than HDPE.

D) LDPE is unbranched and has a higher melting point than HDPE.

9. The pH of solution **X** is 1 and that of **Y** is 2. Which statement is correct about the hydronium ion concentrations in the two solutions?

A) $[H_3O^+]$ in **X** is half that in **Y**.

B) $[H_3O^+]$ in **X** is twice that in **Y**.

C) $[H_3O^+]$ in **X** is one tenth of that in **Y**.

D) $[H_3O^+]$ in **X** is ten times that in **Y**.

10. What is the molar solubility of silver carbonate in a solution of 0.125 mol L^{-1} sodium carbonate?

A) 8.23×10^{-6}

B) 6.77×10^{-11}

C) 8.46×10^{-12}

D) 1.05×10^{-12}

11. Nitrogen gas reacts with hydrogen gas to form ammonia gas in a reversible reaction. 1.50mol of N_2 gas and 0.500mol of H_2 gas are combined in a 0.500L container and left to reach equilibrium. At equilibrium there was 0.3315mol of H_2. What is the value of the equilibrium constant, K?

A) 0.0149

B) 0.0601

C) 0.117

D) 0.239

12. Which of the following statements describes if a reaction can be a reversible reaction?

A) If the activation energies of both the forward and reverse reactions are high

B) If the activation energies of both the forward and reverse reactions are low

C) If the activation energy of the exothermic reaction is high and the endothermic reaction low

D) If the activation energy of the endothermic reaction is high and the exothermic reaction low

13. Which statement(s) is/are true for a mixture of ice and liquid water at equilibrium?

I. The rates of melting and freezing are equal.

II. The amounts of ice and liquid water are equal.

III. The same position of equilibrium can be reached by cooling liquid water and heating ice.

A) I only

B) I and III only

C) II only

D) III only

14. The compounds $H_2NCH_2CH_2NH_2$ and $HOOCCH_2COOH$ react to form a polymer. What is the structure of the repeating unit of the polymer?

A) $-\!\!\!(HNCH_2CONHCH_2CH_2NHCO)\!\!\!-$

B) $-\!\!\!(HNCH_2CH_2NHCOCH_2CO)\!\!\!-$

C) $-\!\!\!(OCCH_2CONHCH_2NHCO)\!\!\!-$

D) $-\!\!\!(HNCH_2CH_2NHCOCH_2NH)\!\!\!-$

15. What will happen if $CO_{2(g)}$ is allowed to escape from the following reaction mixture at equilibrium?

$$CO_{2(g)} + H_2O_{(l)} \rightleftharpoons H^+_{(aq)} + HCO_3^-{}_{(aq)}$$

A) The pH will decrease.

B) The pH will increase.

C) The pH will remain constant.

D) The pH will become zero.

16. The strengths of organic acids can be compared using K_a and pK_a values. Which acid is the strongest?

A)	Acid A	$pK_a = 6$
B)	Acid B	$pK_a = 3$
C)	Acid C	$K_a = 1\times10^{-5}$
D)	Acid D	$K_a = 1\times10^{-4}$

17. The table below gives the results of chemical tests for selected anions and cations.

Ion	**Add 0.1 M Na_2CO_3**	**Add 0.1 M HCl**	**Add 0.1 M KSCN**	**Add 0.1 M $AgNO_3$**
Ca^{2+}	white ppte	no change	no change	no change
Ba^{2+}	white ppte	no change	no change	no change
Pb^{2+}	white ppte	white ppte	no change	no change
Fe^{3+}	brown ppte	no change	red colour	no change
Cl^-	no change	no change	no change	white ppte

(ppte = precipitate)

When the above tests were performed on an unknown solution the following results were obtained.

Add 0.1 M Na_2CO_3	**Add 0.1 M HCl**	**Add 0.1 M KSCN**	**Add 0.1 M $AgNO_3$**
white ppte	no change	no change	white ppte

Which of the conclusions listed is consistent with the results?

A) The solution contained Ca^{2+} only

B) The solution contained $FeCl_3$ only

C) The solution contained both $CaCl_2$ and $BaCl_2$

D) The solution contained both $CaCl_2$ and $PbCl_2$

18. The heat of combustion of ethanol is 1360 kJ mol^{-1}. What mass of ethanol needs to be combusted to raise the temperature of 350.0g of water by 77.0K, if 55% of the heat produced by the combustion reaction is lost to the environment?

A) 3.81g

B) 6.94g

C) 8.48g

D) 184g

19. A student performed an experiment to determine the mass changes that occur when glucose undergoes fermentation. The student's results are given in the table below.

Initial mass of reactant flask and contents (g)	239.86
Final mass of reactant flask and contents (g)	232.20

Based on the student's results, the volume of carbon dioxide gas produced at 0˚C and 100 kPa is closest to:

A) 3.953 L

B) 4.315 L

C) 174.0 L

D) 189.9 L

20. A solution of iron thiocyanate ($FeSCN^{2+}$) is red in colour. It absorbs light at a maximum at a wavelength of 447nm.

Beer's Law shows the relationship between absorbance and concentration. It is written as **A = εbc,** where A is absorbance, ε is the molar absorptivity, b is the path length of the sample and c is the concentration of the compound in solution.

If the absorbance value of an unknown sample is 0.355, and the cuvette used is 1.00cm in width and the molar absorptivity of $FeSCN^{2+}$ is 7.00×10^{3} L mol^{-1} cm^{-1}, using Beer's Law, what is the concentration of the unknown sample in mol L^{-1}?

A) 5.07×10^{-5}

B) 0.0507

C) 2.485

D) 2485

End of Section I

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CRANBROOK SCHOOL

1	2	5

Centre Number

Student Number

2019 | **TRIAL EXAMINATION**

Chemistry

Section II Answer Booklet

80 marks
Attempt Questions 21-33
Allow about 2 hours and 25 minutes for this section

- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the end of this part. If you use this space, clearly indicate which question you are answering.

Question 21 (6 marks)

In your course you modelled dynamic equilibrium.

a) Outline what is meant by the term 'dynamic equilibrium.' **2**

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b) Describe the model you used. **1**

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c) Evaluate your model. **3**

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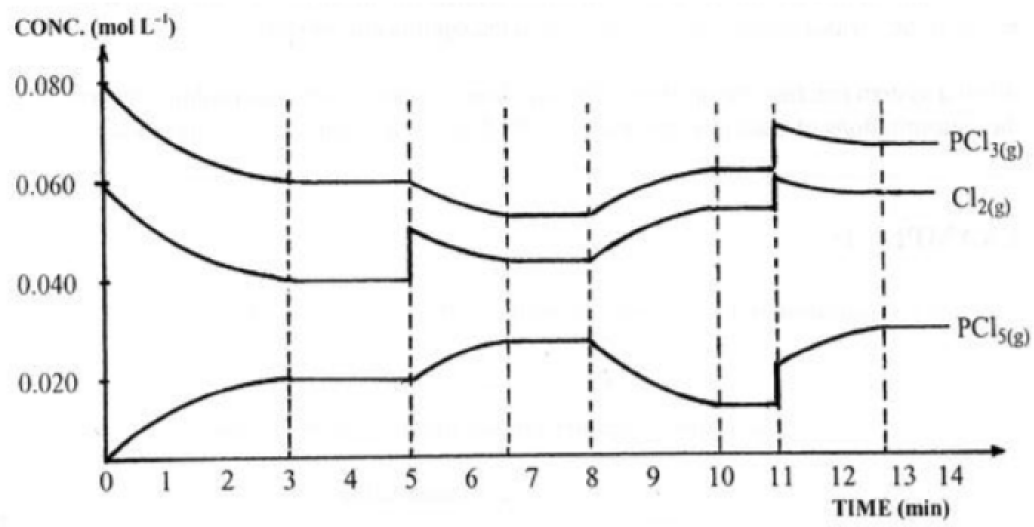
Question 22 (14 marks)

Phosphorus trichloride reacts with chlorine to form phosphorus pentachloride in a reversible reaction. All species are present as gases.

A mixture of 0.080 mol L^{-1} PCl_3 and 0.060 mol L^{-1} Cl_2 were placed in a sealed container at 25°C and left to reach equilibrium. The system was then subjected to various stresses at 5 min, 8 min and 11 min.



a) Write the equation for this reaction. **1**

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b) Calculate the equilibrium constant for this reaction at 25°C. **3**

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c) Explain if the forward reaction is exothermic or endothermic using evidence from the graph to support your answer. **3**

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d) Identify the stress introduced at t=11min and explain the response of the system. **3**

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e) A chemist sets up another container, also at 25°C to carry out the same reaction. At a certain time she measures the concentrations of the three species and finds they are:

$[PCl_3] = 7.50 \times 10^{-3}$ mol L^{-1}
$[Cl_2] = 5.00 \times 10^{-3}$ mol L^{-1}
$[PCl_5] = 2.50 \times 10^{-3}$ mol L^{-1}

Determine if this reaction is at equilibrium, and if not state the reaction that is being favoured. **4**

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Question 23 (4 marks)

A 150.0mL solution of 0.100mol L^{-1} $Pb(NO_3)_2$ is added to a 100.0mL solution of 0.200mol L^{-1} of NaCl. Determine if a precipitate will form.

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Question 24 (6 marks)

A 20.0mL solution of 0.250M H_2SO_4 is added to a 30.0mL solution of 0.500M KOH.

a) Calculate the pH of the resulting solution. **3**

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b) The initial temperature of both solutions was 20.0^{o}C. If the reaction causes the temperature of the solution to rise to 22.5^{o}C, calculate the enthalpy of neutralisation. **3**

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Question 25 (7 marks)

Explain how solutions of acids and bases are analysed.

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Question 26 (3 marks)

Explain how a buffer system works, using equations to support your answer.

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Question 27 (8 marks)

A titration is carried out using sodium hydroxide to determine the concentration of ethanoic acid.

a) Sketch the shape of the pH curve for this titration. **1**

b) Explain, using equations, the best indicator to use for this titration. **3**

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c) The results gathered by the student for this titration are given below:

Table: Titre values of 0.250M NaOH in a titration against 20.00mL aliquots of unknown ethanoic acid

Titration number	Titre volume (mL)
Rough	33.05
1	32.05
2	32.10
3	32.10

Calculate the concentration of the ethanoic acid. **4**

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Question 28 (9 marks)

The tables below show the boiling points of similar mass molecules from the alkenes, the aldehydes and the amines

Alkene	Relative molecular mass ($g.mol^{-1}$)	Boiling Point (°C)
Ethene	28.1	-104
Propene	42.1	-47
But-1-ene	56.1	-6
Pent-1-ene	70.1	30

Aldehyde	Relative molecular mass ($g.mol^{-1}$)	Boiling Point (°C)
Methanal	30	-21
Ethanal	44.1	21
Propanal	58.1	46
Butanal	72.1	75

Amine	Relative molecular mass ($g.mol^{-1}$)	Boiling Point (°C)
Methylamine	31.1	-6
Ethylamine	45.1	17
1-propylamine	59.1	49
1-butylamine	73.1	78

a) Draw structural formulae of the following molecules. **2**

i) Propanal

ii) Ethylamine

b) Use the grid below to graph boiling point against relative molecular mass for all the molecules in the 3 tables on the previous page. Draw a different line of best fit for each homologous series. **3**

c) Account for the differences in the boiling points within and between the 3 homologous series. **4**

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Question 29 (5 marks)

Discuss the environmental, economic and sociocultural implications of obtaining and using hydrocarbons from the Earth.

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Question 30 (5 marks)

In your course you carried out a first-hand investigation to distinguish between alkanes and alkenes.

a) Justify the method you used in this first-hand investigation. **2**

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b) Explain the results that you obtained. **3**

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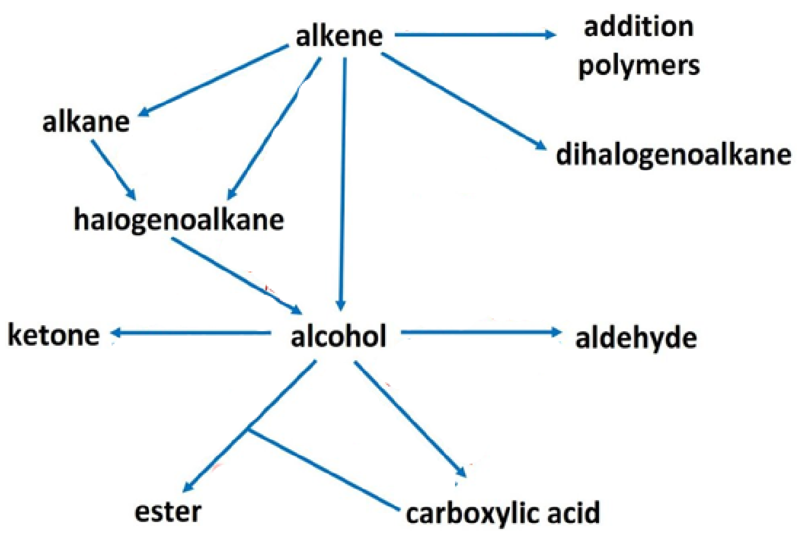
Question 31 (5 marks)

The diagram below shows some possible pathways to get from one organic compound to another



a) Identify an alcohol that can react to form an aldehyde and write an equation for this reaction. **2**

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b) Identify the catalyst needed to produce an alcohol from an alkene. **1**

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c) Identify the reactions in the diagram that require refluxing to be successful. **2**

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Question 32 (5 marks)

A student wants to determine the concentration of a metal ion in a sample of creek water. He makes standard solutions to draw a calibration curve.

His data is shown below:

Concentration (ppm)	Absorbance
2.0	0.15
4.0	0.30
6.0	0.46
8.0	0.61

a) Draw a calibration curve (absorbance v concentration) on the grid below. **1**

b) The sample of creek water is tested and an absorbance value of 0.38 is obtained. Use the graph to determine the concentration of the ion in the creek water. **1**

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c) Compare the effectiveness of AAS and colourimetry in determining the concentration of the metal ions. **3**

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Question 33 (3 marks)

Analyse the need for monitoring the presence of ions in the environment.

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Extra writing space for Section II

2019 Chemistry Trial Exam Marking Guidelines

Test Section	Question	Marks	Outcomes	Targeted Performance Bands	Answer
Section I: Multiple Choice	1	1	CH12-2, CH12-13	3-4	D
	2	1	CH12-14	2-4	D
	3	1	CH12-12	3-4	A
	4	1	CH12-13	3-4	C
	5	1	CH12-14	3-4	B
	6	1	CH12-14	3-4	A
	7	1	CH12-13	3-4	C
	8	1	CH12-14	3-4	C
	9	1	CH12-13	3-4	D
	10	1	CH12-12	3-5	A
	11	1	CH12-12	3-5	B
	12	1	CH12-12	3-5	B
	13	1	CH12-12	3-5	B
	14	1	CH12-14	3-5	B
	15	1	CH12-12	4-5	B
	16	1	CH12-13	4-5	B
	17	1	CH12-15	4-6	C
	18	1	CH12-14	4-6	C
	19	1	CH12-14	4-6	A
	20	1	CH12-15	4-6	A
Section II	21a	2	CH12-12	3-4	
	21b	1	CH12-12	2-3	
	21c	3	CH12-12	3-5	
	22a	1	CH12-12	3-4	
	22b	3	CH12-4, CH12-5, CH12-12	4-6	
	22c	3	CH12-5, CH12-12	4-5	
	22d	3	CH12-5, CH12-12	4-5	
	22e	4	CH12-4, CH12-12	4-6	
	23	4	CH12-4, CH12-12	5-6	
	24a	3	CH12-4, CH12-13	4-6	
	24b	3	CH12-4, CH12-13	3-5	
	25	7	CH12-13	3-6	
	26	3	CH12-13	4-6	
	27a	1	CH12-7, CH12-13	3-4	
	27b	3	CH12-13	3-5	
	27c	4	CH12-5, CH12-13	3-5	
	28a	2	CH12-7, CH12-14	2-3	
	28b	3	CH12-4, CH12-14	3-4	
	28c	4	CH12-14	3-5	
	29	5	CH12-6, CH12-14	4-5	
	30a	2	CH12-2, CH12-14	3-4	
	30b	3	CH12-14	3-5	
	31a	2	CH12-14	3-4	
	31b	1	CH12-14	2-3	
	31c	2	CH12-6, CH12-14	3-4	
	32a	1	CH12-4, CH12-15	2-3	
	32b	1	CH12-5, CH12-15	2-3	
	32c	3	CH12-15	4-5	
	33	3	CH12-6, CH12-15	3-5	

Section I – Multiple Choice

Question 1

You don't need to dry the conical flask because what you need to be certain of in the conical flask is that you have a known number of moles. This is ensured by using a pipette to transfer the aliquot to the flask. Any excess water in the flask will not change the number of moles you add from the pipette.

Question 2

Fermentation is anaerobic – occurs in the absence of oxygen.

Question 3

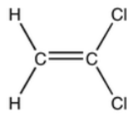
The process of removing the toxin works because it is soluble. As you wash it away it decreases the concentration of the toxin in solution, driving the reaction to produce more soluble toxin.

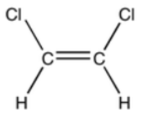
Question 4

The conjugate acid HS^- accepts a proton from water to produce H_2S and OH^-

Question 5

Isomers are the same molecular formula but a different structure. There are two isomers, 1,1-dichloroethene and 1,2-dichloroethene





Question 6

This is esterification. The ester produced is called ethyl butanoate

Question 7

Arrhenius acids and base require solutions (produce H^+/OH^- ions in solution). This is answers A, B and D. Bronsted-Lowry acids and bases do not need to be in solutions. This is the correct answer C.

Question 8

The reason LDPE is low density is that it has branches that prevent the sperate polymer chains form packing in close together. This separation of the chains also reduces the intermolecular force attractions between chains as they are a greater distance from each other.

Question 9

A change of 1 pH unit is a x10 change in $[H_3O^+]$

Question 10

This is the common ion effect

$Ag_2CO_{3\,(s)} \rightleftharpoons 2Ag^+_{(aq)} + CO_3^{2-}{}_{(aq)}$

$Ksp = [Ag^+]^2 [CO_3^{2-}]$ $Na_2CO_{3\,(s)} \rightleftharpoons 2Na^+_{(aq)} + CO_3^{2-}{}_{(aq)}$ therefore $[CO_3^{2-}] = 0.125M$

$[Ag^+] = x$, $[CO_3^{2-}] = 0.125$ M

$Ksp = [Ag^+]^2 [CO_3^{2-}]$
$8.46 \times 10^{-12} = x^2 \times 0.125$

$x^2 = 8.46 \times 10^{-12} / 0.125$
$= 6.768 \times 10^{-11}$

$x = \sqrt{6.768 \times 10^{-11}}$
$= 8.23 \times 10^{-6}$

Question 11

ICE problem. Need to change moles to concentration (it is a 0.500L container). Change row must be in the same ratio as the balanced equation

	$N_{2(g)}$ +	$3H_{2\,(g)}$ $\rightleftharpoons$	$2NH_{3\,(g)}$
I	3.00	1.00	0
C	-0.112	-0.337	+0.225
E	2.888	0.663	0.225

$K = \frac{[NH_3]^2}{[N_2][H_2]^3}$

$= (0.225)^2/(2.888)(0.663)^3$
$= 0.0601\ mol^{-2}L^2$

Question 12

A reaction is more likely to occur if activation energy is low. If both forward and reverse are low, then there is the greatest chance of both happening.

Question 13

By definition, rate of forward and reverse process are the same if at equilibrium (I) but you don't need to have the same concentrations or amounts (II). It doesn't matter if you start with the ice or the water, it will reach the same equilibrium position at the same temperature (III)

Question 14

If you cannot see this easily then it might be better to draw the full structural formula first. The first compound is a diamine and the second is a dicarboxylic acid. The diamine loses a H from each end and the dicarboxylic acid loses an OH from each end. What is left is the repeating unit.

Question 15
If $CO_{2\,(g)}$ escapes, its concentration is reduced. According to LCP, this favours the reaction that increase the CO_2, which is the reverse reaction. This will lower the H^+ concentration, raising the pH.

Question 16
The greater the Ka, the stronger the acid. The lower the pKa, the stronger the acid. pKa=-logKa.

Question 17
The first test adding sodium carbonate means that you could have calcium, barium or lead ions.
The second test adding HCl means it cannot be lead ions which would precipitate
The third test adding KSCN shows you have calcium or barium
The fourth test adding silver nitrate is positive for chloride ions

Question 18
The best way to think about this question is to treat the ΔH not as -1360 but rather 45% of that, which is -612.

$q = mc\Delta T$
$= 0.3500 \times 4.18 \times 10^3 \times 77$
$= 112651$ J
$= 112.651$kJ

$\Delta H = -q/n$
$n = -q/\Delta H$
$= -112.651/-612$
$= 0.184$ mol

$n = m/M$
$m = nM$
$= 0.184 \times 46.068$
$= 8.48$g

Question 19
Mass lost from flask = mass of carbon dioxide formed = 7.66g

$n(CO_2)$ lost $= m/M$
$= 7.66/44.01$
$= 0.174$ mol
$V(CO_2)$ at 0^oC and 10kPa = 22.71 L/mol
$n = v/V$
$v = nV$
$= 0.174 \times 22.71$
$= 3.95$L
Question 20

This question requires you to rearrange Beer's Law and substitute the values

$A = έbc$
$c = A/έb$
$= 0.355 \times (7.00 \times 10^3 \times 1.00)$
$= 5.07 \times 10^{-5}$

Section II – 80 marks

Question 21 (6 marks)
21 (a) (2 marks)

Criteria	Marks
Gives the main features of dynamic equilibrium referring to no macroscopic changes (no change in concentrations) but microscopic changes occurring at the same rate (forward and reverse reactions)	2
Refers to a reversible reaction OR rates of forward and reverse reaction equal	1

Sample answer

In a closed system, a reversible reaction will reach a state of equilibrium. At this point, the rate of the forward reaction is equal to the rate of the reverse reaction. There appears to be no change occurring as the overall concentrations of reactants and products stay the same, but at the particle level reactants and products are changing into each other at the same rate. This is known as dynamic equilibrium – no macroscopic change but microscopic change.

21 (b) (1 marks)

Criteria	Mark
Gives the main characteristics/features of an acceptable model	1

Sample answer

2 containers, 1 initially with water and the other no water. 2 different sized beakers were used to transfer water from one to the other until equilibrium was reached

21 (c) (3 marks)

Criteria	Marks
Makes a clear judgement statement on how well the model represents the real process of equilibrium, supported by detailed valid criteria based on specific aspects of equilibrium without contradiction	3
Makes a clear judgement statement on how well the model represents the real process of equilibrium, supported by detailed valid criteria based on specific aspects of equilibrium with contradictions OR Makes a judgement statement on how well the model represents the real process of equilibrium, supported by some valid criteria OR Discusses in detail strengths and limitations to make a vague judgement No judgement statement but good description of strengths or weaknesses of model	2
Provides some brief points on why the model is good or bad	1

Sample answer

This model is very good at representing the real process of equilibrium. This is because it showed an number of the components of equilibrium including reversibility of reaction (pouring the water) reactants and products (the 2 containers) and reaching an unchanging state (water levels don’t change)

Question 22 (14 marks)

22 (a) (1 mark)

Criteria	Marks
Correct equation with reversible arrow and states	1

Sample answer

$PCl_{3\,(g)} + Cl_{2\,(g)} \rightleftharpoons PCl_{5\,(g)}$

22 (b) (3 marks)

Criteria	Marks
Reads concentrations correctly from graph, writes correct equilibrium equation or working and correctly calculates K (units not penalised) to 2 significant figures	3
Reads concentrations correctly from graph, writes correct equilibrium equation or working and correctly calculates K (units not penalised) with incorrect significant figures	2
Partially correct	1

Sample answer

At 25°C: $C(PCl_3) = 0.060 \text{ mol L}^{-1}$
$C(Cl_2) = 0.040 \text{ mol L}^{-1}$
$C(PCl_5) = 0.020 \text{ mol L}^{-1}$

$$K = \frac{[PCl_5]}{[PCl_3]\,[Cl_2]}$$

$= 0.020/(0.060 \times 0.020)$
$= 8.3 \text{ mol}^{-1} \text{ L}$

22 (c) (3 marks)

Criteria	Marks
Identifies that at t=8min was a temperature stress and that it favoured the reverse reaction and states that there is not enough information to determine which direction is exothermic AND Explains the enthalpy of the forward reaction if the stress is an increase in temperature and if the stress is a decrease in temperature	3
Identifies that at t=8min the temperature was raised or cooled and that it favoured the reverse reaction and explains this correctly in terms of Le Chatelier's Principle	2
Some correct information	1

Sample answer

At t=8min there was a temperature stress (no instantaneous changes in concentration), which caused the reverse reaction to be favoured.
You cannot determine from the graph is the stress was adding heat or cooling.

If heat was added, according to Le Chatelier's Principle this would favour the reaction that removes heat which is the endothermic reaction. This would make the forward reaction exothermic.

If heat was removed (surroundings cooled), according to Le Chatelier's Principle this would favour the reaction that releases heat to the surroundings which is the exothermic reaction. This would make the forward reaction endothermic.

22 (d) (3 marks)

Criteria	Marks
Correctly identifies that the stress is an increase in pressure (all gaseous system) and explains why the system shifts right to reduce pressure because it produces less moles of gas	3
Identifies the stress is an increase in concentration and explains why the system shifts right to produces less moles	2
Some correct information	1

Sample answer

As all 3 gases increase in concentration, the volume must have been decreased so the stress introduced is an increase in pressure.
According to Le Chatelier's Principle, this stress will be opposed and favour the reaction that decreases pressure. This is the reaction that produces the least moles of gas, which is the forward reaction.

22 (e) (4 marks)

Criteria	Marks
Correctly calculates Q with working and identifies that the system is not at equilibrium AND Correctly states that the reverse reaction is favoured	4
3 of the above	3
2 of the above	2
1 of the above	1

Sample answer

$$Q = \frac{[PCl_5]}{[PCl_3]\,[Cl_2]}$$

$= 2.50 \times 10^{-3}/(7.50 \times 10^{-3} \times 5.00 \times 10^{-3})$
$= 66.7\ mol^{-1}\ L$

Q is not equal to K, so the reaction is not at equilibrium, Q > K, so reverse reaction is favoured

Question 23 (4 marks)

Criteria	Marks
Writes correct equation and predicts precipitate formed based on solubility rules and Correctly uses dilution formula to calculate concentrations of the ions involved in possible precipitation and Writes correct net ionic equation for precipitation reaction and Writes correct Q expression and correctly calculates Q and Correctly identifies Q > K, so precipitate will form	4
Minor mistake but all the above included	3
Most of the above	2
Some of the above	1

Sample answer

Predict a precipitate of lead chloride according to solubility rules

$Pb(NO_3)_{2\,(aq)} + 2NaCl_{\,(aq)} \rightarrow PbCl_{2\,(s)} + 2NaNO_{3\,(aq)}$

Need ion concentrations of Pb^{2+} and Cl^- to confirm

$Pb(NO_3)_2$: $C_1V_1=C_2V_2$

$0.100 \times 0.1500 = C_2 \times 0.2500$

$C_2 = 0.0600 \text{ mol L}^{-1} = [Pb^{2+}]$

NaCl : $C_1V_1=C_2V_2$

$0.200 \times 0.1000 = C_2 \times 0.2500$

$C_2 = 0.0800 \text{ mol L}^{-1} = [Cl^-]$

$PbCl_{2\,(s)} \rightleftharpoons Pb^{2+}{}_{(aq)} + 2Cl^-{}_{(aq)}$

$Q_{sp} = [Pb^{2+}]\,[Cl^-]^2$

$= 0.0600 \times (0.0800)^2$

$= 3.84 \times 10^{-4}$

$K_{sp} = 1.70 \times 10^{-5}$

$Q_{sp} > K_{sp}$, therefore precipitate will form

Question 24 (6 marks)

24 (a) (3 marks)

Criteria	Marks
Writes correct balanced equation to determine moles of both reactants and correctly determines the limiting reagent as sulfuric acid Correctly calculates the moles of excess potassium hydroxide and uses this to correctly calculate the concentration of hydroxide ions in excess Correctly calculates the pH from the hydroxide ion concentration	3
Most of the above but uses moles not concentration to calculate incorrect pH or Most of the above but uses wrong excess moles	2
Some of the above	1

Sample answer

$H_2SO_{4\,(aq)} + 2KOH_{\,(aq)} \rightarrow K_2SO_{4\,(aq)} + 2H_2O_{\,(l)}$

$n(H_2SO_4) = cv$
$= 0.250 \times 0.0200$
$= 5.00 \times 10^{-3}$ mol

$n(KOH) = cv$
$= 0.500 \times 0.0300$
$= 1.50 \times 10^{-2}$ mol

Ratio H_2SO_4 : KOH
1: 2
$5.00 \times 10^{-3} : 1.00 \times 10^{-2}$ this works, sulfuric acid limiting
$7.50 \times 10^{-3} : 1.50 \times 10^{-2}$ too much sulfuric acid required

Excess KOH = $1.50 \times 10^{-2} - 1.00 \times 10^{-2}$
$= 5.00 \times 10^{-3}$ mol

$KOH_{\,(s)} \rightarrow K^+_{(aq)} + OH^-_{(aq)}$

$n(OH^-) = 5.00 \times 10^{-3}$ mol
$v(OH^-) = 0.0500$ L

$c(OH^-) = n/v$
$= 5.00 \times 10^{-3}/0.0500$
$= 0.100$ mol L^{-1}

$[H_3O^+][OH^-] = 10^{-14}$
$[H_3O^+] = 10^{-14}/[OH^-]$
$= 10^{-14} / 0.100$
$= 10^{-13}$ mol L^{-1}

pH = $-\log [H_3O^+]$
$= -\log 10^{-13}$
$= 13.000$ (3sf)

24 (b) (3 marks)

Criteria	Marks
Correctly calculates heat flow (q) and correctly calculates moles of sulfuric acid to determine enthalpy of neutralisation with correct units	3
Most of the above	2
Some correct information/calculations	1

Sample answer

q = ?
m = 0.0500kg (50 mL of solution)
c = 4.18×10^{-3} J kg^{-1} K^{-1}
ΔT = 22.5-20.0
= 2.50K

q = $mc\Delta T$
= $0.0500 \times 4.18 \times 10^{-3} \times 2.50$
= 522.5 J

ΔH = ?
q = 0.5225 kJ
n = moles of water produced in neutralisation
= $2 \times 5.00 \times 10^{-3}$ mol
= 1.00×10^{-2} mol

$\Delta H = -q/n$
= $-0.5225 / 1.00 \times 10^{-2}$
= -52.3 kJ mol^{-1}

Question 25 (7 marks)

Criteria	Marks
5 or more techniques for analysing acids/bases mentioned and detailed information describing the relationship between the techniques and their purpose provided. Includes thorough explanation of titration	7
4 techniques for analysing acids/bases mentioned and detailed information describing the relationship between the techniques and their purpose provided. Includes detailed explanation of titration as one of the techniques	6
4 techniques, including titration, briefly described OR 3 techniques for analysing acids/bases mentioned and information describing the relationship between the techniques and their purpose provided. Includes detailed explanation of titration as one of the techniques	5
3 techniques included, with a brief description of titration OR 2 techniques included with a detailed explanation of titration	4
3 techniques described. Titration not included OR Detailed description of titration	3
Brief description of titration OR 2 techniques described. Titration not included	2
1 technique described. Titration not included.	1

Sample answer

Solutions of acids and bases can be analysed in many qualitative and quantitative ways. The main quantitative technique is titration where the concentration of an unknown acid or base is determined through a neutralisation reaction using very accurate technique of volumetric analysis using a burette. This technique also uses a qualitative technique of analyzing acids/bases which is indicators. Indicators are normally weak acids that have a different colour to their conjugate base depending on the pH. Measuring pH with a pH meter or probe is another quantitative technique to analyse acids and bases. If the pH is below 7 the solution is an acidic, if the pH is greater than 7 the solution is basic. Acids and bases can also be analysed using conductivity meters to give an indication of the strength of the acid or base, as strong acids/bases dissociate to a greater extent into ions, which conduct more. Another way that acids and bases are analysed is using Ka/Kb and pKa/pKb. Ka/Kb is a measure of the position of equilibrium, the lower the value, the weaker the acid or base. Acids and bases can also be analysed by looking at their properties such as taste and feel. Acids taste sour and burn the skin. Bases taste bitter and feel slippery. They can also be analysed by their reactions such as acid + metal producing hydrogen gas and acid + carbonate producing carbon dioxide gas. Finally, acids and bases have been analysed using categorising them using different theories, such as Arrhenius (producing H+ or OH- ions in solution) and Bronsted-Lowry (donating or accepting a proton).

Question 26 (3 marks)

Criteria	Mark
Outlines the components of buffer system, including the reversible buffer equation and explains the response to adding both acid and base (a concentration stress) in terms of LCP, linking this to resisting a change in pH	3
Most of the above included	2
Some correct information	1

Sample answer

A buffer system is made of a weak acid or a weak base with an equal number of moles of the salt of that weak acid or weak base added. A weak acid or weak base reversible reaction is set up.

For the ethanoic acid/ethanoate ion buffer system, the buffer equation is:

$$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$$

If a strong acid is added, the concentration of H_3O^+ rises which potentially would dramatically decrease pH. According to Le Chatelier's Principle, this stress on the system is opposed, favouring the reaction that reduces the $[H_3O^+]$. This is the reverse reaction, so this reduces the effect of adding acid and a pH change is resisted.

If a strong base is added, the concentration of H_3O^+ falls as the OH^- ions react with the H_3O^+ in a neutralisation reaction which potentially would dramatically increase the pH. According to Le Chatelier's Principle, this stress on the system is opposed, favouring the reaction that increases the $[H_3O^+]$. This is the forward reaction, so this reduces the effect of adding base and a pH change is resisted.

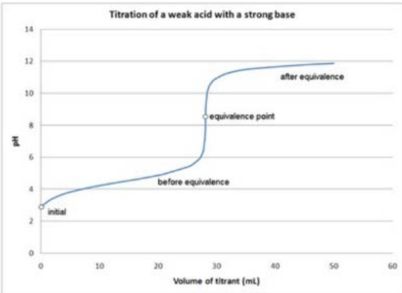
The presence of the salt of the weak acid or weak base is to ensure that all the salt ion is not used up too quickly if the reverse reaction occurs, enabling the buffer to resist pH change to a greater extent.

Question 27 (8 marks)

27 (a) (1 mark)

Criteria	Marks
Correctly drawn curve with correct labels	1

Sample answer



27 (b) (3 marks)

Criteria	Marks
Identifies phenolphthalein as the best indicator Explains that the end point of phenolphthalein is basic and this matches the pH of the neutralised solution at the equivalence point Provides an equation to show the ethanoate ion reacting with water to produce hydroxide ion and links this to the basic salt solution	3
Identifies phenolphthalein as the best indicator Explains that the end point of phenolphthalein is basic and this matches the pH of the neutralised solution in a strong base-weak acid titration	2
Identifies phenolphthalein as the best indicator	1

Sample answer

The best indicator for this titration would be phenolphthalein. This is because the end point of phenolphthalein (8.3-10.0) is in the range of the pH at the equivalence point because a strong base v weak acid titration produces a basic salt.

The salt is basic because the conjugate base of the weak acid ethanoic acid is strong so it reacts with water by accepting a proton:

$$CH_3COO^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COOH_{(aq)} + OH^-{}_{(aq)}$$

The presence of the hydroxide ions raises the pH, so it is basic.

The sodium ion formed in the titration is the weak conjugate acid of the strong base sodium hydroxide, so does not react with water and therefore has no effect on the pH.

27 (c) (4 marks)

Criteria	Marks
Correctly calculates average titre value using the 3 concordant volumes Write correct equation Calculates moles of known (NaOH) Recognises 1:1 ratio to determine moles of unknown (CH_3COOH) Calculates moles of unknown	4
All of the above with a minor mistake	3
Most of the above	2
Some correct steps	1

Sample answer

Average titre value = (32.05 + 32.10 + 32.10) / 3
= 32.08 mL

$NaOH_{(aq)} + CH_3COOH_{(aq)} \rightarrow CH_3COONa_{(aq)} + H_2O_{(l)}$

$n(H_2SO_4)$ = cv
= 0.250 x 0.03208
= 0.00802 mol

Ratio NaOH : CH_3COOH
1: 1

$n(CH_3COOH)$ = 0.00802 mol
$v(CH_3COOH)$ = 0.02000 L

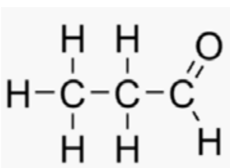
c = n/v
= 0.00802 / 0.02000
= 0.401 mol L^{-1}

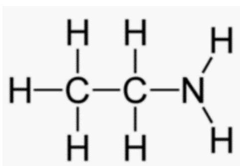
Question 28 (9 marks)

28 (a) (2 marks)

Criteria	Marks
Both structural formulae correct	2
One structural formula correct	1

Sample answer

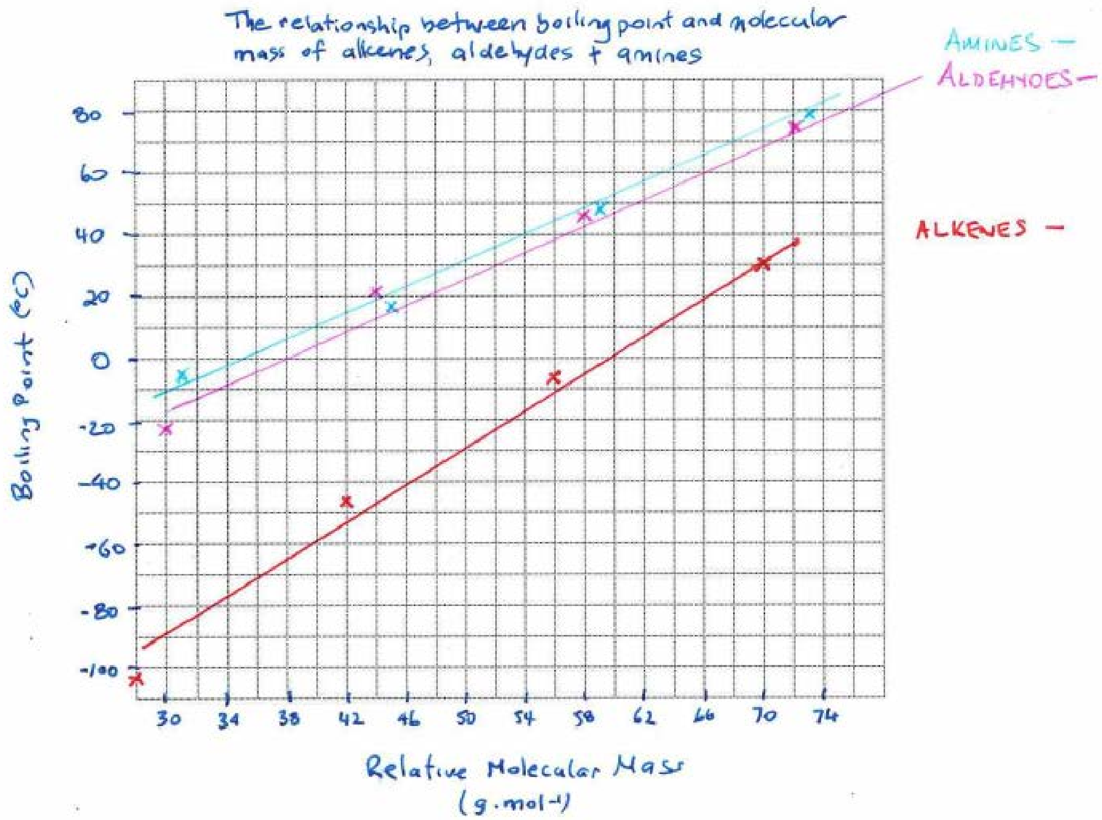




28 (b) (3 marks)

Criteria	Marks
Correctly formatted graph (labels, units, scale, title) with correctly plotted points and valid curves drawn with a key provided	3
Mostly correct	2
Partially correct	1

Sample answer



28 (c) (4 marks)

Criteria	Marks
Gives correct reasons (type of intermolecular force) for -the increasing boiling point in all three groups (dispersion forces) -the lowest values of the alkenes (dispersion force) -the higher values of the aldehydes (dipole-dipole force) -the highest values of the amines (hydrogen bond)	4
Correctly gives reasons for 3 of the above	3
Correctly gives reasons for 2 of the above	2
Correctly gives reason for 1 of the above	1

Sample answer

Boiling point depends on the strength of the intermolecular forces between molecules. The increasing bp trend in all 3 groups is due to the increasing size of the dispersion forces due to more electrons as there are more atoms.
Alkenes have the lowest bp because they contain only non-polar C-C and C-H bonds. Therefore the only IMF between alkene molecules is dispersion forces which are the weakest so require the lowest amount of heat to break. Aldehydes and amines have similar boiling points, with amines slightly higher. The aldehydes possess the polar C=O bond. This permanent dipole means that it can form dipole-dipole attractions with other aldehydes which are stronger than dispersion forces, so more heat is required to separate these molecules. Amines possess the polar N-H bond. This gives rise to the strongest IMF of hydrogen bonding between amine molecules, requiring the most heat energy to break apart from each other.

Question 29 (5 marks)

Criteria	Marks
Gives clear, well written, balanced points for and against all factors; environmental, economic and sociocultural implications for both obtaining and using hydrocarbons.	5
Gives balanced points for and against most factors; environmental, economic and sociocultural implications for both obtaining and using hydrocarbons.	4
Gives points for and against some factors including environmental, economic and sociocultural implications for both obtaining and using hydrocarbons.	3
Gives a point for and/or against using hydrocarbons of an environmental, economic and sociocultural implication.	2
States a positive or negative of using hydrocarbons	1

Sample answer

Criteria	Points for	Points against
Environmental	The use of hydrocarbons has not had a positive impact on the environment.	The extraction of fossil fuels from underground sources, e.g. coal, and the subsequent burning of these fuels for energy has led to an increase in atmospheric carbon dioxide levels. There is evidence to suggest this is the main contributor to climate change would has significant consequences for weather events and living organisms.
Economic	The extraction of hydrocarbons from Earth was and continues to being a booming business that provides many jobs for people, in Australia and overseas, and the sale and trade of hydrocarbons for various uses has boosted nations' economies.	The heavy reliance on hydrocarbons may have stifled required developments in renewable and alternative energy technologies as hydrocarbons are a non-renewable resource.
Sociocultural	Fossil fuels are a 'raw material' which humans have used for many technologies that have improved communication and travel around the world. As a raw material many plastics and medicines may have been able to been developed as a result.	Human reliance on hydrocarbons has meant that their extraction has been prioritized over protecting Indigenous sacred sites and land in Australia and overseas. There has also been conflict between countries over fossil fuels.

Question 30 (5 marks)

30 (a) (2 marks)

Criteria	Mark
Gives the reason for carrying out the main listed steps of the experiment	2
Gives the reason for some of the main steps OR Writes a thorough method for the experiment	1

Sample answer

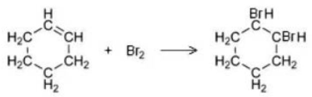
Step 1: 5 mL of bromine water was added to 2 different test tubes
Justification: This is the coloured solution used to distinguish alkanes and alkenes (bromine water test)
Step 2: The room was darkened
Justification: The distinguishing test requires no UV light to be present
Step 3: 5 mL of cyclohexane and 5 mL of cyclohexene were added to the 2 different test tubes and shaken
Justification: These are the substances being tested
Step 4: Observations were made
Justification: The distinguishing test is qualitative

30 (b) (3 marks)

Criteria	Marks
Links the colour change of the alkene addition reaction with the reactive C=C bond and therefore no need for UV light. Links the lack of colour change of the alkane substitution reaction to the less reactive C-C bond, so only occurs if the energy input of UV light is provided. Equations included.	3
Links the colour change of the alkene addition reaction with the reactive C=C bond and therefore no need for UV light. Links the lack of colour change of the alkane substitution reaction to the less reactive C-C bond, so only occurs if the energy input of UV light is provided	2
Some correct information	1

Sample answer

Cyclohexene reacts with bromine water in an addition reaction to form the colourless 1,2-dibromcyclohexane. This does not require UV light due to the reactivity of the C=C double bond.



Cyclohexane contains the less reactive C-C single bond, so requires an input of UV light for the substitution reaction to occur. This is why the reaction did not occur in the dark and the colour of the unreacted bromine water remained, allow the alkane and alkene to be distinguished.

Question 31 (5 marks)

31 (a) (2 marks)

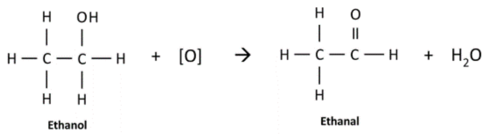
Criteria	Mark
Correctly identifies a primary alcohol and writes a correct equation	2
Correctly identifies a primary alcohol	1

Sample answer

Ethanol

$$\underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow[\text{[O]}]{K_2Cr_2O_7/H_2SO_4} \underset{\text{Ethanal}}{CH_3CHO}$$

OR



31 (b) (1 marks)

Criteria	Mark
Correctly names dilute acid catalyst	1

Sample answer

Dilute sulfuric acid

31 (c) (2 marks)

Criteria	Mark
Correctly identifies 3-4 reactions that require refluxing	2
Identifies 1-2 reactions	1

Sample answer

Four reactions require the use of refluxing:

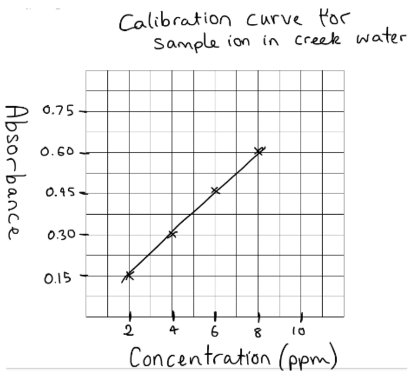
- Oxidation of secondary **alcohol** to a **ketone**
- Oxidation of primary **alcohol** to only form a **carboxylic acid** (no intermediate aldehyde)
- Esterification reaction of **alcohol** and **carboxylic acid**
- **Halogenoalkane** substitution reaction to form **alcohols**

Question 32 (5 marks)

32 (a) (1 mark)

Criteria	Mark
Correctly plots absorbance and concentration with equal increments and a line of best fit	1

Sample answer



32 (b) (1 mark)

Criteria	Mark
Correctly uses line of best fit to determine concentration	1

Sample answer
5ppm (Units not required)

32 (c) (3 marks)

Criteria	Mark
Gives three valid criteria to compare AAS and colourimetry in terms of their effectiveness to determine the concentration of metal ions	3
Gives two valid criteria to compare AAS and colourimetry in terms of their effectiveness to determine the concentration of metal ions	2
Gives one valid criterion to compare AAS and colourimetry in terms of their effectiveness to determine the concentration of metal ions	1

Sample answer

Criteria	**AAS**	**Colourimetry**
Light source	Hollow Cathode Lamp emitting specific wavelengths	Visible Light- certain colour filters available
Detection method	Absorbance of wavelength	Absorbance of wavelength
Detects concentration of	Metal ions (does not have to be coloured)	Coloured solutions (required coloured solution, reagent may need to be added)
Precision/Accuracy	Higher	Lower
State of sample	Solution	Solution

Question 33 (3 marks)

Criteria	Marks
Identifies the need to use science to monitor ions in the environment (not just for human health), using a specific example. Draws out clear relationships between the ion, monitoring it and the consequences if it is not monitored.	3
Identifies the need to monitor ions, with a named example. Draws out a relationship between an ion and consequences if not monitored.	2
Identifies the importance of monitoring ions, supported with an example.	1

Sample answer

Certain metal and non-metal ions can cause significant environmental damage, even if present in small amounts. It is important to monitor for the presence and concentration of these ions to ensure ecosystems and human health are maintained. Phosphate and nitrate ions, originally in fertilizers, can enter waterways through runoff and may accumulate in these systems. These ions support algae growth. Once the algae dies, bacteria use up the oxygen in the water as part of their metabolic processes and oxygen depletion causes fish deaths as they suffocate. This has a significant impact of the water quality and wider food web of the particular ecosystem affected.