Student Number……...

Mark……...

Chemistry

2019 Term 4
Working Scientifically

General Instructions

- Reading time – 5 minutes
- Working time – 70 minutes
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A Formulae sheet, data sheet and periodic Table are provided
- Answer questions in the spaces provided. These spaces provide guidance for the expected length of your response
- Show all relevant working in questions involving calculations
- Extra working space is provided at the back of the exam booklet. If you use this space, clearly indicates which question you are answering.

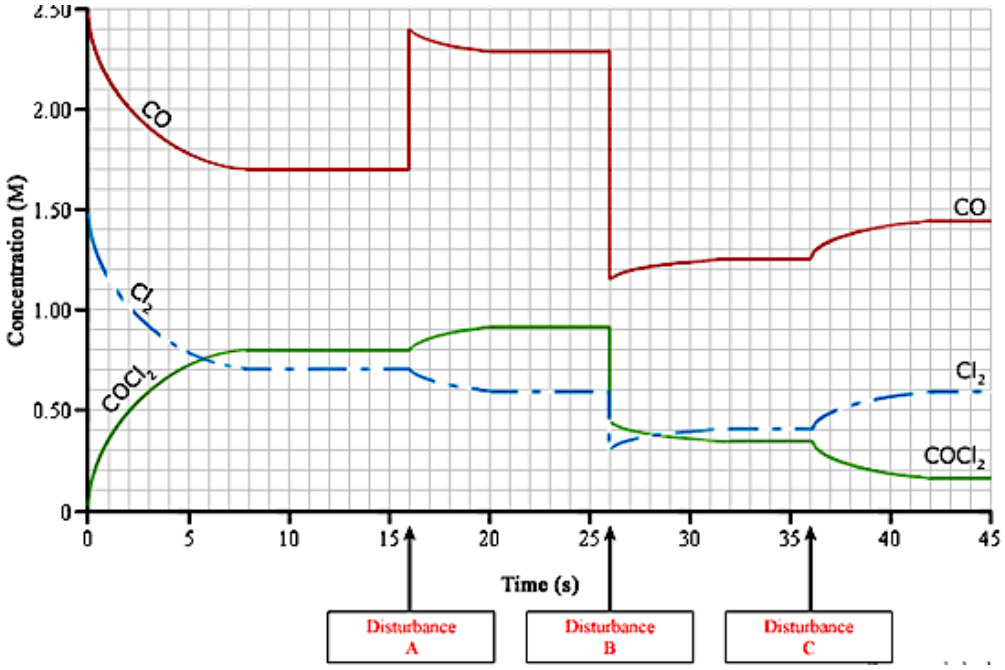
Attempt 3 Questions 1-3

Total Marks – 43

Question 1 (12 marks)

Carbon monoxide and chlorine gases react to form gaseous phosgene in an equilibrium reaction. The reaction is exothermic.

The graph shows this reaction and three disturbances made to the established equilibrium.



(a) Write an equation for the initial reaction on the graph. **1**

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(b) The position of equilibrium can be quantified using the equilibrium constant expression.
For the reaction $aA + bB \rightleftarrows cC + dD$, the equilibrium constant expression is

$$K_{eq} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

Write the equilibrium expression and calculate the equilibrium constants for the reaction at 15, 35 and 45 minutes. **4**

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(c) Identify which disturbance condition affects the equilibrium constant. **1**

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(d) Le Chatelier's Principle states that if a system at equilibrium is disturbed, ie, the conditions are changed, the equilibrium will adjust to oppose the change.

Identify the three disturbances A, B and C, placed on this equilibrium and justify the shifts in equilibrium using Le Chatelier's Principle. **6**

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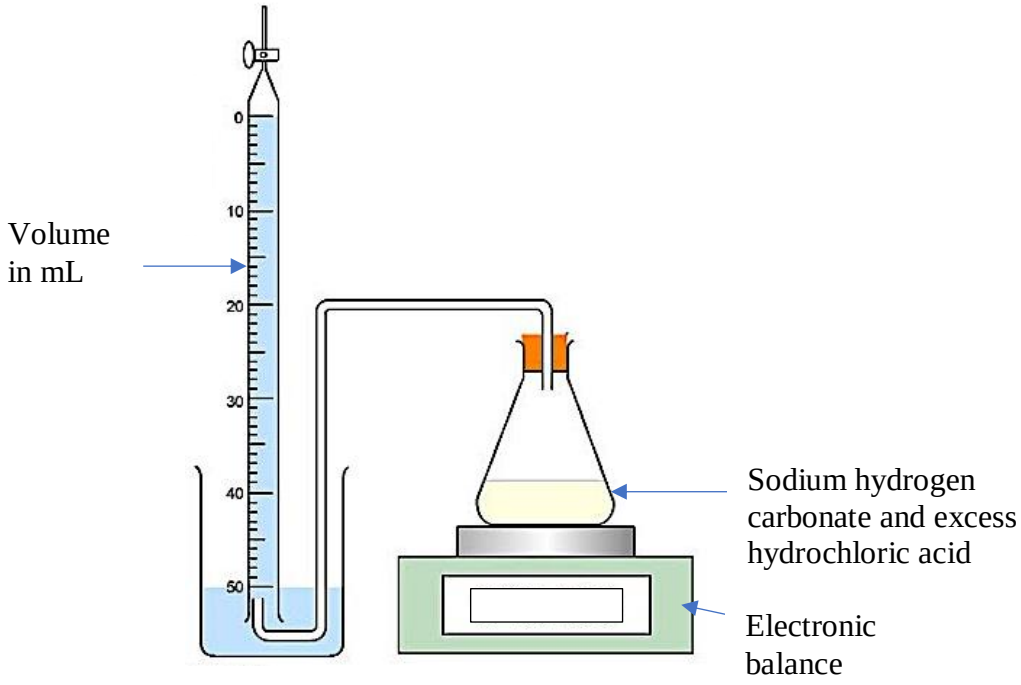
Question 2 (12 marks)

A student wanted to determine the purity of bicarb soda (sodium hydrogen carbonate) bought in the supermarket compared to chemical grade sodium hydrogen carbonate from the chemical store at school.

She used the following set up to collect her results at 25°C and 100 kPa.



Excess hydrochloric acid was used for each experiment, 10.0 mL of 0.10 $molL^{-1}$ solution. Both the volume of gas generated and the change in mass of the reaction were measured.

Results

0.050 g of solids	*Volume of gas generated (mL)*	*% purity*	*Mass of gas lost (g)*	*% purity*
McKent bicarb soda	12.0		0.022	
Wings bicarb soda	13.5	91.5	0.025	95
Chemical grade sodium hydrogen carbonate	14.5	98.3	0.026	99
Theoretical results	14.75	100	0.0262	100

(a) Calculate the purity of the solid from both the gas volume generated and the mass change for McKent bicarb soda. **4**

(i) Purity calculated from the gas volume generated.

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(ii) Purity calculated from the mass change.

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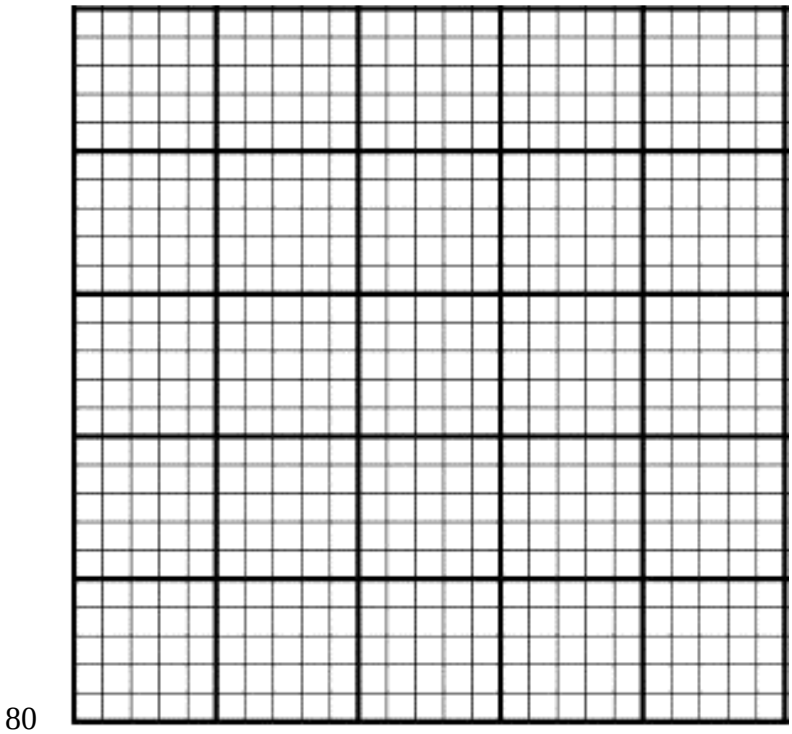
Question 2 continues on page 6

(b) Use a column graph to show the % purity of the three different solids and the theoretical results from the mass change data on page 4. **4**



(c) Identify the independent variable in this experiment. **1**

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(d) Discuss the differences in the calculated purity of each sample from the two different dependant variables measured. **3**

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Question 3 (19 marks)

The equilibrium constant for the solubility product of silver ethanoate ($AgCH_3COO$) was determined using the following method.

Method

1. Thoroughly clean a length of copper wire with emery paper and wind it into a coil.
2. Weigh the coil on an electronic balance and record the mass.
3. Measure out 100.0 mL of saturated silver ethanoate solution in a measuring cylinder and pour it into a 250 mL beaker.
4. Set the room temperature to 25°C. Record the temperature of the solution.
5. Suspend the copper coil in the solution, as pictured, and allow the reaction to proceed overnight.

6. Wash all the silver crystals free of the copper wire using distilled water from a wash bottle.
7. Rinse the wire in a beaker of acetone and allow it to dry in air (this thoroughly dries the copper).
8. Weigh the wire on an electronic balance.
9. Pour off the liquid into a waste beaker and rinse the silver crystals and wash them into another waste beaker.
10. Repeat the procedure twice.

The following results were obtained.

(a) Complete the table for the mass changes in each reaction at 25°C **1**

Initial mass of copper coil (g)	*Final mass of copper coil (g)*	*Mass change (g)*
28.195	28.021	
28.021	27.848	
27.848	27.673	

Question 3 continues on page 6

(b) Calculate the average mass change of the copper coil. **1**

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(c) Write a net ionic equation for the reaction occurring in the beaker. **1**

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(d) Calculate the moles of copper used in the reaction. **1**

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(e) Calculate the concentration of silver ions in mol L^{-1} in the original saturated solution. **2**

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(f) The solubility product (Ksp) for a salt can be determined using the following process.

$$AB\ (s) \rightleftarrows A^+\ (aq) + B^-(aq)$$

$$Ksp = [A^+][B^-]$$

Write the Ksp expression for silver ethanoate. **1**

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(g) Calculate the Ksp for silver ethanoate. **1**

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(h) Outline a qualitative observation that could be made as the reaction proceeds. **1**

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(h) Assess the accuracy, validity and reliability of the experiment, given that the Ksp literature value is 3.0×10^{-3} for silver ethanoate at 25°C **6**

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(i) The solubility of silver ethanoate is 1.02 g /100 g of water at 20°C.

Determine whether the dissolution of silver ethanoate is exothermic or endothermic and justify your answer. **4**

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End of paper

Working Scientifically - Extra writing space

If you use this space, clearly indicate which question you are answering.

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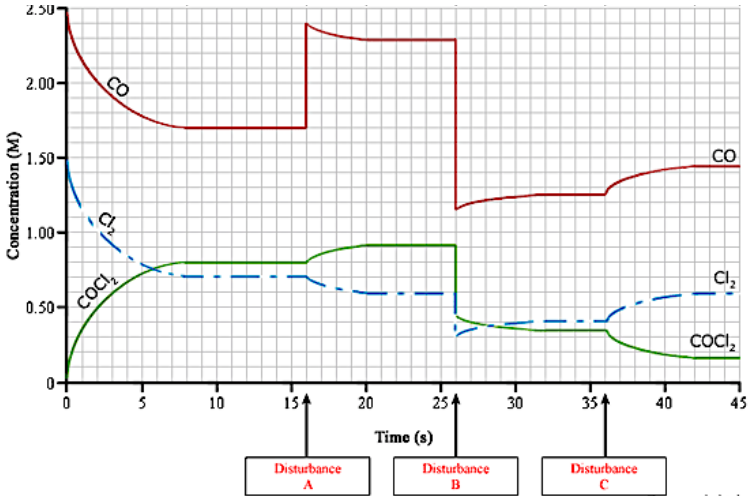
Working Scientifically Answers Term 4 2019

Question 1 (12 marks)

Carbon monoxide and chlorine gases react to form phosgene in an equilibrium reaction. The reaction is exothermic.

The graph shows this reaction and three disturbances made to the established equilibrium.



(a) Write an equation for the initial reaction on the graph. **1**

$$CO\ (g) + Cl_2(g) \rightleftarrows COCl_2\ (g)$$

Marking Criteria	*Marks*
• Correct equation with equilibrium arrows	1

(b) The position of equilibrium can be quantified using the equilibrium constant expression.
For the reaction aA + bB ⇄ cC + dD, the equilibrium constant expression is

$$K_{eq} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

Write the equilibrium expression and calculate the equilibrium constants for the reaction at 15, 35 and 45 seconds. **4**

$$K_{eq} = \frac{[COCl_2]}{[CO][Cl_2]}$$

K at 15 minutes $= \frac{0.8}{1.7 \times 0.7} = 0.67$

K at 35 minutes $= \frac{0.34}{1.25 \times 0.4} = 0.68$

K at 45 minutes $= \frac{0.15}{1.45 \times 0.6} = 0.172$

Marking Criteria	*Marks*
• Gives the equilibrium expression and correctly calculates the constants at 15, 35 and 45 minutes	4
• Gives the equilibrium expression and correctly calculates two constants OR • Correctly calculates the three constants without giving the equilibrium expression	3
• Gives the equilibrium expression and correctly calculates one constant OR • Correctly calculates the two constants without giving the equilibrium expression	2
• Gives some calculation or the equilibrium expression	1

(c) Identify which disturbance condition effects the equilibrium constant. **1**

Temperature (disturbance C)

Marking Criteria	*Marks*
• Identifies temperature	1

(d) Le Chatelier's Principle states that if a system at equilibrium is disturbed, ie, the conditions are changed, the equilibrium will adjust to oppose the change.

Identify the three disturbances A, B and C placed on this equilibrium and justify the shifts in equilibrium using Le Chatelier's Principle. **6**

Sample answer

$$CO\,(g) + Cl_2(g) \rightleftarrows COCl_2\,(g)$$

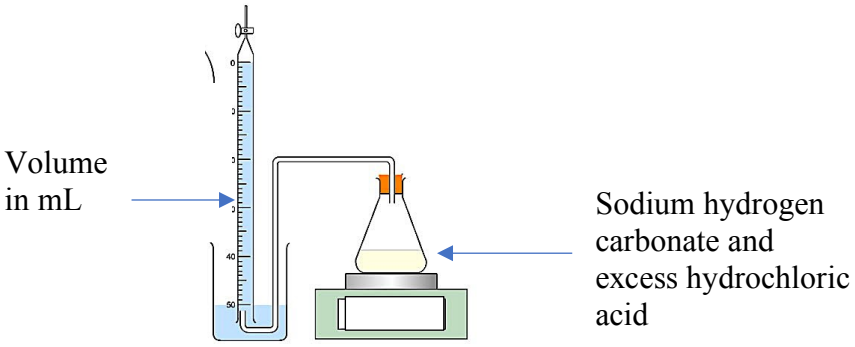
Disturbance A is an increase in the [CO] gas.
Equilibrium shifts to oppose the change (Le Chatelier) ie to use up some CO. The reaction that uses CO is the forward reaction and equilibrium shifts to the right making more $COCl_2$, concentration increases, and using up some CO and Cl_2, concentration decreases.
Disturbance B is a decrease in pressure as the concentrations of all gases goes down.
Equilibrium shifts to oppose the change, ie to increase the pressure. The reaction that exerts more pressure is the one producing more gas molecules, is the reverse reaction 2:1.
Equilibrium shifts to the left and the concentration of $COCl_2$ goes down and the concentrations of the reactants increase.
Disturbance C is an increase in temperature.
Equilibrium shifts to oppose the change, ie to lower the temperature by using heat. The reaction which uses heat is the endothermic reaction which is the reverse reaction and equilibrium shifts to the left, increasing the concentration of the reactants and decreasing the concentration of the $COCl_2$.

Marking Criteria	*Marks*
• Identifies the three disturbances and • Justifies the three shifts in equilibrium using Le Chatelier's Principle	6
• Identifies the three disturbances and • Justifies two shifts in equilibrium using Le Chatelier's Principle and outlines the third	5

• Justifies two shifts in equilibrium using Le Chatelier's Principle	4
• Outlines some shifts in equilibrium	3
• Identifies some disturbances	2
• Gives some relevant information	1

Question 2 (13 marks)

A student wanted to determine the purity of bicarb soda (sodium hydrogen carbonate) bought in the supermarket compared to chemical grade sodium hydrogen carbonate from the chemical store at school.
She used the following set up to collect her results at 25°C and 100kPa.



Excess hydrochloric acid was used for each experiment, 10.0 mL of 0.10 $molL^{-1}$ solution.

Both the volume of gas generated and the change in mass of the reaction were measured.

Results

0.050 g of solids	*Volume of gas generated (mL)*	*% purity*	*Mass of gas lost (g)*	*% purity*
McKent bicarb soda	12.0	81.3	0.022	84
Wings bicarb soda	13.5	91.5	0.025	95
Chemical grade sodium hydrogen carbonate	14.5	98.3	0.026	99
Theoretical results	14.75	100	0.0262	100

(a) Calculate the purity of the solid from both the gas volume generated and the mass change for McKent bicarb soda. **4**

(i) $NaHCO_3(s) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l) + CO_2(g)$

Molar mass $NaHCO_3$= 22.99 + 12.01 + 1.008 + 3(16) = 84.008 g

McKent Volume CO_2 = 12.0 mL

Mol CO_2 = V/24.79 = 4.84 x 10^{-4} mol

Therefore mol $NaHCO_3$ = 4.84 x 10^{-4} mol

Mass = mol x molar mass = 4.84 x 10^{-4} x 84.008 = 0.04066

% purity = mass/initial mass x 100 = 0.04066/0.05 x 100 = 81.3%

(ii)Molar mass CO_2= 12.01 + 2(16) = 44.01g

McKent mass CO_2 = 0.022 g

Mol CO_2 = mass/molar mass = 0.022/44.01 = 4.998 x 10^{-4} mol

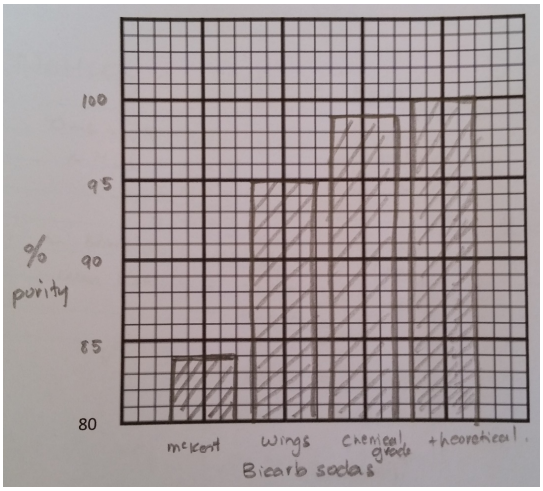
Therefore mol $NaHCO_3$ =

Mass = mol x molar mass = 4.998x 10^{-4} x 84.008 = 0.04199

% purity = mass/initial mass x 100 = 0.04199/0.05 x 100 = 83.9%

Marking Criteria	*Marks*
• Shows all relevant working for both calculations	4
• Shows most relevant working for both calculations	3
• Shows all relevant working for one calculation OR • Shows some relevant working for both calculations	2
• Gives a balanced equation or some relevant working	1

(b) Use a column graph to show the % purity of the three different solids and the theoretical results from the mass change data on page 4. **4**



Marking Criteria	*Marks*
• Labels axes correctly • Uses an appropriate scale • Graphs data accurately • Presents data in a column graph	4
• Provides a substantially correct graph (includes THREE correct feature)	3
• Provides a partially correct graph (includes TWO correct features)	2
• Includes ONE correct feature.	1

(c) Identify the independent variable in this experiment. **1**

The brand / type / source of bicarb soda

Marking Criteria	*Marks*
• Correctly identifies the independent variable	1

(d) Discuss the differences in the calculated purity of each sample from the two different dependant variables measured. **3**

Sample answer

Although the percent purity correlates across the two variables, gas volume and mass ie, the McKent is the least pure, followed by Wings, with the Chemical grade as the most pure. The calculated % purity is relatively higher for all the samples from the mass measurements. This may be due to loss of the gas from the system giving a lower volume, some of the gas dissolving in the water or the less accurate measure of the gas compared to the mass, eg the volume can only be measured in mL +/- 0.5 mL whereas the mass is measured to 0.001g

Marking Criteria	*Marks*
• Discusses the difference in calculated purity between the two dependent variables for each sample. • Accounts for difference between calculated purity between the two dependent variables.	3
• Outlines the difference in the calculated purity between the two dependent variables and accounts for this difference. **OR** • Outlines the difference in the calculated purity for each sample and provides a reason for the difference between mass and volume data.	2
• Provides some relevant information	1

Question 3 (19 marks)

The equilibrium constant for the solubility product of silver ethanoate ($AgCH_3COO$) can be determined using the following method.

Method

1. Thoroughly clean a length of copper wire with emery paper and wind it into a coil.
2. Weigh the coil on an electronic balance and record the mass.
3. Measure out 100.0 mL of saturated silver ethanoate solution in a measuring cylinder and pour it into a 250 mL beaker.
4. Set the room temperature to 25°C. Record the temperature of the solution.
5. Suspend the copper coil in the solution, as pictured, and allow the reaction to proceed overnight.

6. Wash all the silver crystals free of the copper wire using distilled water from a wash bottle.
7. Rinse the wire in a beaker of acetone and allow it to dry in air. (thoroughly dries the copper)
8. Weigh the wire on an electronic balance.
9. Pour off the liquid into a waste beaker and rinse the silver crystals and wash them into another waste beaker.
10. Repeat the procedure twice. The following results were obtained.

Initial mass of copper coil (g)	*Final mass of copper coil(g)*	*Mass change (g)*
28.195	28.021	*(-) 0.174*
28.021	27.848	*(-) 0.173*
27.848	27.673	*(-) 0.175*

(a) Complete the table for the mass changes in each reaction at 25°C. **1**

Marking Criteria	*Marks*
• Three correct mass changes	1

(b) Calculate the average mass change of the copper coil. **1**

Average mass change = $\frac{0.174 + 0.173 + 0.175.}{3}$ = 0.174 g

Marking Criteria	*Marks*
• Correctly calculates the average	1

(c) Write a net ionic equation for the reaction occurring in the beaker. **1**

$$Cu\ (s) + 2Ag^{+} \rightarrow Cu^{2+.} + 2Ag\ (s)$$

Marking Criteria	*Marks*
• Correct net ionic equation	1

(d) Calculate the moles of copper used in the reaction. **1**

Mol Cu = Mass/molar mass = 0.174/63.55 = 2.738×10^{-3}

Marking Criteria	*Marks*
• Correct calculation of the moles of copper	1

(e) Calculate the concentration of silver ions in mol L^{-1} in the original saturated solution. **2**

Therefore mol Ag = 2 x mol Cu = $2 \times 2.738 \times 10^{-3} = 5.476 \times 10^{-3.}$ in 100 mL

$[Ag^{+}] = 5.476 \times 10^{-2}$ mol L^{-1}

Marking Criteria	*Marks*
• All relevant working shown for the correct calculation of silver ions	2
• Some calculation shown	1

(f) The solubility product (Ksp) for a salt can be determined using the following process.

$$AB\ (s) \rightleftarrows A^+\ (aq) + B^-\ (aq)$$

$$Ksp = [A^+][B^-]$$

Write the Ksp expression for silver ethanoate. **1**

$$Ksp = [Ag^+][CH_3COO^-]$$

Marking Criteria	*Marks*
• Correct Ksp expression	1

(g) Calculate the Ksp for silver ethanoate. **1**

$$[Ag^+] = [CH_3COO^-]$$

$$Ksp = [Ag^+][CH_3COO^-] = (5.476 \times 10^{-2})^2 = 3.00 \times 10^{-3}$$

Marking Criteria	*Marks*
• Correct Ksp 3 sig figs	1

(h) Outline a qualitative observation that could be made as the reaction proceeds. **1**

The solution will become blue as copper ions enter the solution. OR
Silver crystals appear on the copper wire.

Marking Criteria	*Marks*
• One qualitative observation	1

(h) Assess the accuracy, validity and reliability of the experiment, given that the Ksp literature value is 3.0×10^{-3} for silver ethanoate at 25°C **6**

Sample answer
Accuracy- The method is very accurate as it produced results that were the same as the literature value at the same temperature and used accurate equipment to take the measurements ie the electronic balance that can weigh to .001g
Reliability – the procedure is reliable as it was repeated, and the results replicated.
Validity – the procedure was valid in that, when followed, the Ksp of silver ethanoate could be determined. All variables were kept constant including room temperature to ensure the Ksp calculated could be compared to the literature value at 25°C

Marking Criteria	*Marks*
• Assesses the accuracy, reliability and validity of the procedure to determine Ksp for silver ethanoate.	6
• Assesses the accuracy, and either reliability or validity of the procedure to determine Ksp for silver ethanoate.	5
• Describes the accuracy, reliability and validity of the procedure	4
• Outlines some of the features of the procedure	3
• Outlines one of the features of the procedure	2
• Gives some relevant information	1

(i) The solubility of silver ethanoate is 1.02 g /100 g of water at 20°C.
Determine whether the dissolution of silver ethanoate is exothermic or endothermic and justify your answer. **4**

At 25°C
Molar mass $AgCH_3COO$ = 107.9 + 2(12.01) + 2(16) + 3(1.008) =166.944
The $[AgCH_3COO]$ is 5.476 x 10^{-2} mol L^{-1}
$[AgCH_3COO]$ in g/L = mol x molar mass/L =5.476 x 10^{-2} x 166.944 = 9.14 gL^{-1}
$[AgCH_3COO]$ in g/100g = 0.914g/100g

0.914g/100g at 25°C is less than 1.02g/100g at 20°C therefore silver ethanoate is more soluble at a lower temperature. The dissolution must therefore be exothermic as less solid dissolves as temperature increases.

Other calculations include $[Ag^+]$ at 20°C 0.061 $molL^{-1}$ or Ksp 3.733 x 10^{-3} at 20°C

Marking Criteria	*Marks*
• Correctly identifies the reaction as exothermic and • Justifies this identification through calculation and comparison	4
• Correctly identifies the reaction as exothermic and • Justifies this identification with some calculation and comparison OR • Valid justification for an incorrect calculation	3
• Gives some relevant calculations OR • Some justification for the nature of the dissolution	2
• Identifies the reaction as exothermic OR • Gives some relevant information	1