Neap:

Trial Examination 2016

VCE Chemistry Unit 2

Written Examination

Question and Answer Booklet

Reading time: 15 minutes
Writing time: 1 hour 30 minutes

Student's Name: Pea Chise

Teacher's Name: Walter White

Structure of Booklet

Section	*Number of questions*	*Number of questions to be answered*	*Marks*	*Suggested time (minutes)*
A	20	20	20	25
B	5	5	55	65
			Total 75	Total 90

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.

Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.

Materials supplied

Question and answer booklet of 17 pages.

Data booklet of 4 pages.

Answer sheet for multiple-choice questions.

Instructions

Write your **name** and your **teacher's name** in the space provided above on this page, and on the answer sheet for multiple-choice questions.

All written responses must be in English.

At the end of the examination

Place the answer sheet for multiple-choice questions inside the front cover of this booklet.
You may keep the data booklet

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

SECTION A – MULTIPLE-CHOICE QUESTIONS

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is **correct** or that **best answers** the question.
A correct answer scores 1, an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.

Question 1

At 20°C, the solubility of ammonia (NH_3) gas is 52.9 g per 100 g of water and for hydrogen chloride (HCl) gas is 47.3 g per 100 g water. Consider the following statements about these gas solubilities.

I These gas solubility values are typical of all gases at 20°C.

II At 10°C, the solubility of ammonia will be lower than 52.9 g per 100 g water.

Which of these statements are correct?

A. I only
B. II only
C. I and II
D. neither I nor II

Question 2

What percentage of all of the water on Earth is fit for human consumption?

A. less than 5%
B. between 5% and 15%
C. between 15% and 25%
D. over 25%

Question 3

The pH of two strong acids (HNO_3 and H_2SO_4) and one weak acid (H_2CO_3) were measured in a laboratory experiment. The pH of 0.01 M HNO_3 was found to be 2.

Which one of the following is correct?

	pH of 0.01 M H_2SO_4	pH of 0.01 M H_2CO_3
A.	2	2
B.	higher than 2	higher than 2
C.	higher than 2	lower than 2
D.	lower than 2	higher than 2

Use the following information to answer Questions 4 and 5.

The specific heat capacities (SHC) of some substances are shown in the table below.

Substance	copper	water	ethanol	iron
SHC ($J\ g^{-1}\ °C^{-1}$)	0.39	4.2	2.4	0.45

Question 4

The amount of energy, in J, needed to raise the temperature of 1.5 kg of water at 17.5°C to its boiling point at 1 atm pressure is

A. 1.1×10^2

B. 5.2×10^2

C. 1.1×10^5

D. 5.2×10^5

$E = mc\Delta T$

$= 1500 \times 4.18 \times 82.5$

$= 517275\ J.$

Question 5

Consider the following statements about the information in the table above:

I Comparing the two molecular compounds ethanol and water, it can be concluded that water has the stronger covalent bonds.

II If the same amount of energy was applied to 10 g of each substance in the table, copper would have the greatest increase in temperature.

III Water is used in cooling systems in cars because it has a comparatively high specific heat capacity.

Which of these statements are correct?

A. I and II only

B. II and III only

C. I, II and III

D. none of I, II or III

Question 6

The hydrogen sulfate ion, HSO_4^-, is an amphiprotic ion. The equations below show two possible reactions of the ion with water.

I $HSO_4^-(aq) + H_2O(l) \rightarrow H_2SO_4(aq) + OH^-(aq)$

II $HSO_4^-(aq) + H_2O(l) \rightarrow SO_4^{2-}(aq) + H_3O^+(aq)$

An aqueous solution of sodium hydrogen sulfate turns litmus red in colour.

From this information it may be concluded that the reaction occurring in the solution is

A. predominantly I.

B. predominantly II.

C. both I and II to the same extent.

D. neither I nor II.

Use the following information to answer Questions 7 and 8.

An experiment was conducted to determine which metals (identified by the letters W, X, Y and Z) would displace the metal ions from aqueous solutions of various compounds. The results are shown below.

Metals	$FeSO_4(aq)$	$Pb(NO_3)_2(aq)$	$CuSO_4(aq)$
W	no reaction	displacement	displacement
X	no reaction	no reaction	no reaction
Y	displacement	displacement	displacement
Z	no reaction	no reaction	displacement

Question 7

The order of reactivity of the metals from most reactive to least reactive is

A. Y > W > Z > X
B. W > X > Y > Z
C. X > Z > W > Y
D. X > Y > W > Z

Question 8

When a silver nitrate solution is tested with each of the metals separately, silver metal is formed consistently. This means that silver metal

A. is a weaker reducing agent than the other metals.
B. will displace ions of W, X, Y and Z from solution.
C. is more reactive than W, X, Y and Z.
D. is formed when silver ions transfer electrons to the other metals.

Question 9

Which of the following items is **not** used when preparing a standard solution of the primary standard potassium hydrogen phthalate for use in a volumetric analysis?

A. a volumetric flask
B. a pipette
C. deionised water
D. an accurate balance

Question 10

A redox reaction occurs when magnesium is reacted with hydrochloric acid:

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

Which of the following statements about this reaction is correct?

A. A conjugate redox pair is Mg and HCl
B. Magnesium has been oxidised by hydrogen ions.
C. The oxidation reaction is shown by the half-equation $Mg + 2e^- \rightarrow Mg^{2+}$
D. Chloride ions are acting as the reductant.

Question 11

What volume of water, in mL, must be added to 35 mL of 3.5 M K_2CO_3 solution to produce a solution with a concentration of 1.2 M?

A. 12
B. 47
C. 67
D. 102

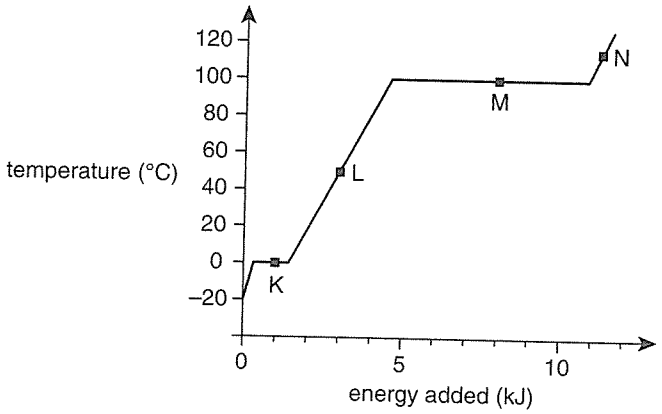
$C_1V_1 = C_2V_2$

$V_2 = \frac{C_1V_1}{C_2} = \frac{3.5 \times 35}{1.2} = 102\,mL$

$102 - 35 = 67\,mL$

Use the following information to answer Questions 12 and 13.

A sample of ice in a beaker was heated continuously and the temperature of the contents of the beaker was recorded at set intervals. The data were plotted to produce the graph below with various points labelled K, L, M and N.



Question 12

Which point is located on a section of the graph associated with the latent heat of vaporisation of water?

A. K
B. L
C. M
D. N

Question 13

Which one of the following is **incorrect**?

	Point	Events relating to the identified section of the graph
A.	K	A change of state is occurring with bonds being disrupted.
B.	L	Heating causes the water molecules to move faster.
C.	M	Intermolecular forces are being disrupted by heating.
D.	N	Covalent bonds have been broken as heating continues.

Question 14

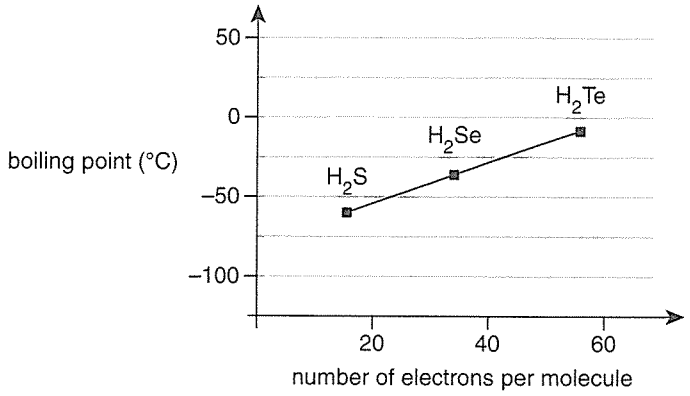
The concentration of Na^+ ions, in g L^{-1}, in 150 mL of 0.0013 M Na_3PO_4 solution is

A. 5.85×10^{-4}
B. 0.0135
C. 0.0897
D. 2.02

$n(Na^+) = 3 \times 0.0013 \times 0.150$
$= 0.00585\,mol$
$[Na^+] = 3 \times 0.0013 = 0.0039\,mol\,L^{-1}$
$m = Mn = 25.0 \times 0.0034 = 0.0897\,g$

Use the following information to answer Questions 15 and 16.

The graph below shows variation in the boiling points of some group 16 hydrides.



Question 15

Which type of interaction is mostly responsible for the trend in boiling points of the hydrides shown in the graph?

A. covalent bonds
B. dispersion forces
C. hydrogen bonding
D. dipole-dipole attraction

Question 16

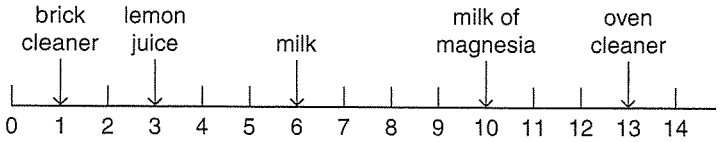
It can be estimated from the graph that water (a group 16 hydride) should have a boiling point well below –50°C.

Which one of the following statements best accounts for water's exceptionally high boiling point of +100°C?

A. Water is a small molecule with very strong covalent bonds joining the atoms together.
B. There are strong dispersion forces between the water molecules because they are packed tightly.
C. The partial charges on the atoms of this polar molecule result in intense intermolecular interactions.
D. Water molecules, unlike the other hydrides, exhibit dipole-dipole attractions between molecules.

Question 17

The approximate pH values (at 25°C) of a range of substances are shown below.



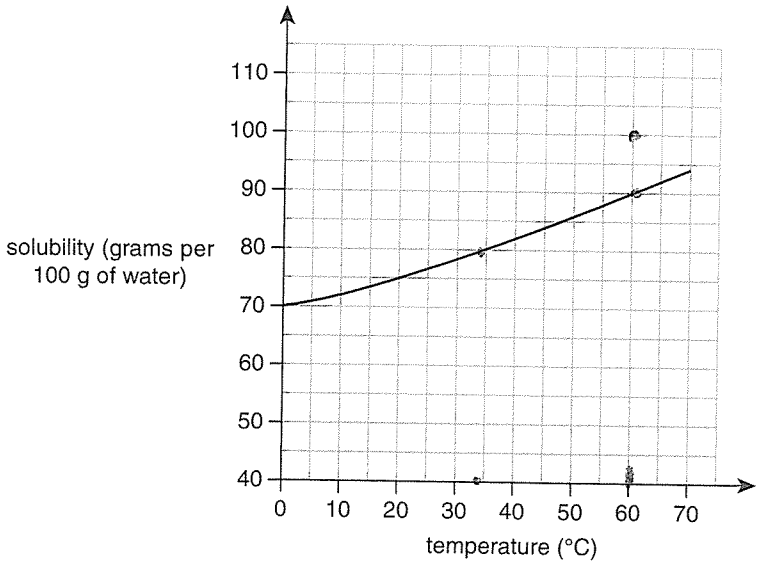
Brick cleaner contains a strong acid.

Which one of the following statements is **correct**?

A. A solution of pH 5 is produced by adding 10 mL of brick cleaner to 40 mL of water.
B. Milk has twice the concentration of hydrogen ions that lemon juice has.
C. Milk of magnesia and oven cleaner are alkalis and so contain no hydrogen ions.
D. The molar concentration of the H_3O^+ ion in brick cleaner is equal to the molar concentration of the OH^- ion in oven cleaner at 25°C.

Use the following information to answer Questions 18 and 19.

The solubility curve for ammonium sulfate is shown below.



Question 18

In one experiment, 40 g of ammonium sulfate was heated in 50 g of water until all of the solid was dissolved. The solution was allowed to cool.

What is the lowest temperature at which all of the solid remains dissolved?

A. 15°C
B. 25°C
C. 35°C
D. 50°C

50 g / 100 g

Question 19

In another experiment, 75 g of ammonium sulfate was added to 75 g of water at 60°C and stirred until no further dissolving took place.

How many grams of solid remained undissolved?

A. 7.5 g
B. 10.5 g
C. 15 g
D. 22.5 g

75 g (75 g = 100 g / 100 g
= 10 g undissolved
x 0.75 = 7.5 g

Question 20

A solution was made by dissolving 7.65 g of ethanol (C_2H_5OH) in water to a total volume of 60.0 mL.

Given that the density of ethanol is 0.785 g mL^{-1}, which one of the following shows an **incorrect** value for the concentration of the solution?

A. 12.8 mg mL^{-1}
B. 12.8% m/v
C. 16.2% v/v
D. 1.28×10^5 ppm

$\frac{7650}{60}$ = 127.5 mg mL^{-1}

SECTION B – SHORT-ANSWER QUESTIONS

Instructions for Section B

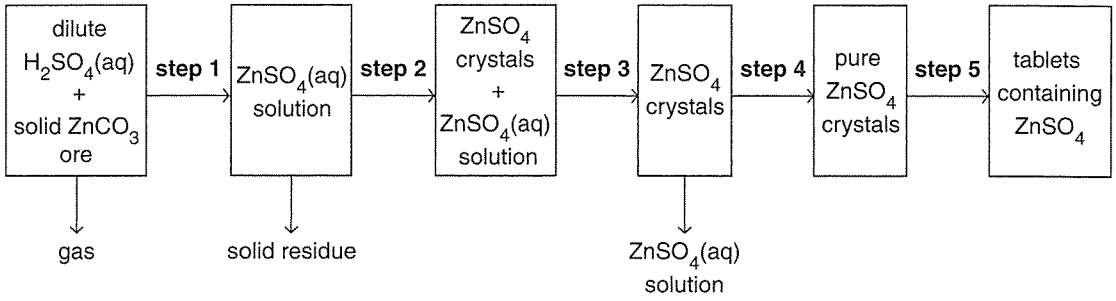
Answer **all** questions in the spaces provided. Write using black or blue pen.

To obtain full marks for your responses, you should:

- give simplified answers, with an appropriate number of significant figures, to all numerical questions; unsimplified answers will not be given full marks
- show all working in your answers to numerical questions; no marks will be given for an incorrect answer unless it is accompanied by details of the working
- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example, $H_2(g)$, NaCl(s).

Question 1 (11 marks)

The flowchart below shows the main steps in the manufacture of tablets containing zinc ions as zinc sulfate. An ore, composed mainly of zinc carbonate, has been used as the starting material in the process.



a. Write a balanced equation for the initial chemical reaction occurring between the zinc carbonate in the ore and sulfuric acid (H_2SO_4). 2 marks

$ZnCO_3(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + CO_2(g) + H_2O(l)$

b. Why was the mixture obtained from the ore/acid reaction filtered in step 1? 1 mark

To separate the solid components from the $ZnSO_4$ solution

c. Suggest a possible procedure used in step 2. 1 mark

Cooling / evaporation of water.

d. A saturated solution of zinc sulfate has been produced in step 2.

Explain the meaning of the term 'saturated'. 1 mark

Contains as much dissolved substance as is possible at that T.

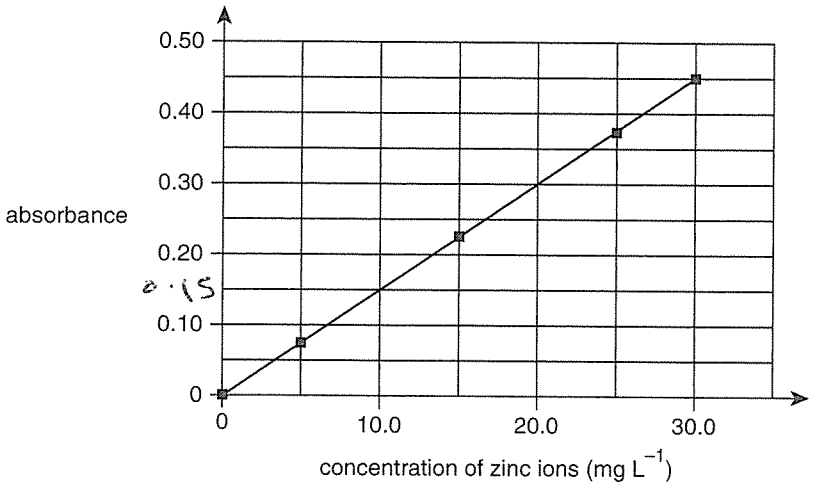
e. Step 4 involved washing the zinc sulfate crystals with a small volume of cold water.

Explain why the volume was small and the water was cold. 2 marks

So that the $ZnSO_4(s)$ did not have sufficient V of H_2O or high enough T to re-dissolve back into the water.

f. The zinc content of tablets produced in step 5 was determined accurately by atomic absorption spectroscopy (AAS) using the method listed below.

- After five tablets were dissolved in acid, the solution was filtered and made up to a final volume of 100.0 mL.
- A sample of this solution gave an absorbance of 0.15 using AAS.
- The calibration graph shown below was used in the analysis.



i. What is the concentration of zinc ions (in mg L^{-1}) in the 100.0 mL of solution made by dissolving the five tablets? 1 mark

10.0 mg L^{-1}.

ii. Calculate the average mass of zinc ions in each tablet. 2 marks

10.0 mg L^{-1} = 1.00 mg / 100 mL.

÷ 5 = 0.200 mg / tablet

iii. Why is it necessary to use a calibration graph in AAS? 1 mark

So that the absorbance readings can be related to a concentration of zinc.

Question 2 (17 marks)

The water from a dam on a farm was analysed for water quality. Three separate 100.0 mL samples were taken for analysis.

a. In order to produce accurate results, strict protocols were followed during the collection of the water samples.

Outline **two** of the important steps which should have been followed when collecting water samples for analysis. 2 marks

eg - collect a representative sample
- wash collection bottle out with the water being collected before retaining the sample.
(if testing for O_2 this needs to be 'fixed' at the site due to biochemical oxygen demand.)

b. To determine the amount of solids dissolved in the water, one 100.0 mL sample was filtered and the resultant liquid was evaporated to dryness in an evaporating basin. The results are shown below.

mass of evaporating basin	42.19 g
mass of evaporating basin and solid	42.67 g

i. Calculate the percentage by mass of the total dissolved solids in the water from the dam. You may assume that the density of the water from the dam is 1.0 g mL^{-1}. 2 marks

$42.67 - 42.19 = 0.48$ g

$\frac{0.48}{102.0} \times 100 = 0.48$ % w/w.

ii. What step could be taken to improve the accuracy of the value calculated in part **b. i.**? 1 mark

oven → reweigh to constant mass.

c. The second 100.0 mL sample of water from the dam was analysed for phosphate ion (PO_4^{3-}) concentration. The phosphate ion in the water can be reacted with a special reagent to produce a coloured solution. The absorbance of the coloured solution is measured to find the phosphate ion concentration. The results of the analysis of the sample and a number of standard solutions containing the phosphate ion are shown below.

	Standard 1	Standard 2	Standard 3	Standard 4	Sample
Phosphate ion concentration ($mg\ L^{-1}$)	0.05	0.10	0.15	0.20	?
Absorbance	0.103	0.205	0.308	0.410	0.331

The calibration process produced a straight-line graph with the relationship:

absorbance = 2.05 × concentration

The recommended maximum concentration of phosphate ion in water is 1.04×10^{-6} M.

Does the water from the dam comply with this limit? Show any working. 2 marks

NO

$c = \frac{abs}{2.05} = \frac{0.331}{2.05} = 0.161\ mg\ L^{-1}$.

$n = \frac{m}{M} = \frac{0.000161}{95.0} = 1.70 \times 10^{-6}\ M$.

d. The remaining 100.0 mL water sample was analysed for the chloride ion (Cl^-) concentration. An excess of silver nitrate solution ($AgNO_3(aq)$) was added to the water sample. The silver chloride precipitate that formed was isolated, washed and dried. The mass of the precipitate was 0.698 g.

i. Write the ionic equation for the precipitation reaction. 1 mark

$Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)}$

ii. Why was it important to add an excess of silver nitrate solution to the water sample? 1 mark

to ensure all the Cl^- had precipitated as $AgCl$

iii. Calculate the chloride ion concentration in the dam water in parts per million (ppm). 3 marks

$n(AgCl) = \frac{0.698}{143.4} = 0.00487\ mol$. $= n(Cl^-)$

$m(Cl^-) = 35.5 \times 0.00487 = 0.173\ g$ in 100.0 mL.

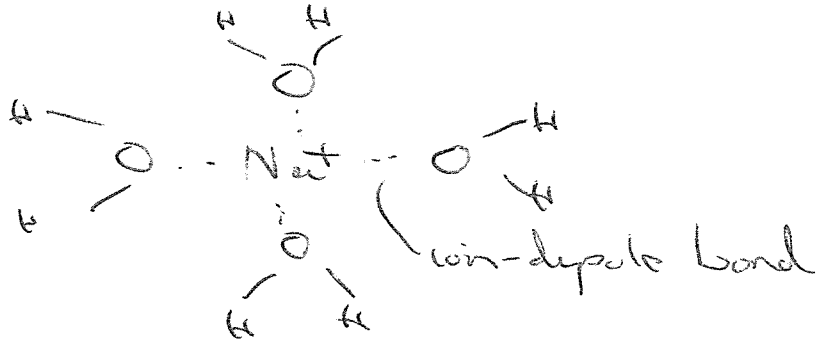
$\Rightarrow 1.73\ g/L = 1730\ mg/L = ppm$.

$= 1.73 \times 10^3\ ppm$.

$\frac{35.5}{143.4} \times 0.698 = 0.173\ g$.

e. Sodium chloride is an ionic compound which is readily soluble in water.

With the aid of a diagram of water molecules and the sodium ion, explain the process of sodium chloride dissolving in water. 3 marks



- ionic bonds between Na^+ and Cl^- broken
- hydrogen bonds between water molecules broken
- new ion-dipole bonds form between Na^+ and H_2O as per the diagram (also applies to Cl^-)

f. Electrical conductivity can be used as an indicator of the salinity of a water sample.

Given samples of water from the dam, describe how electrical conductivity could be used in a laboratory to determine the salinity of the water in the dam. 2 marks

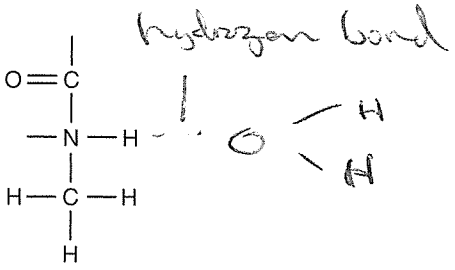
e.c. ∝ salinity
prepare a series of standards of NaCl
→ calibration curve
plot samples on graph to determine salinity

Question 3 (9 marks)

Pesticides are used in agriculture to prevent insects destroying crops. Information about a particular pesticide is shown in the table below.

Brand name	Formula	Molar mass	Solubility in water	Toxicity in humans
aldicarb	$C_7H_{14}N_2O_2S$	190.1 g mol^{-1}	high	low doses: serious illnesses high doses: fatal

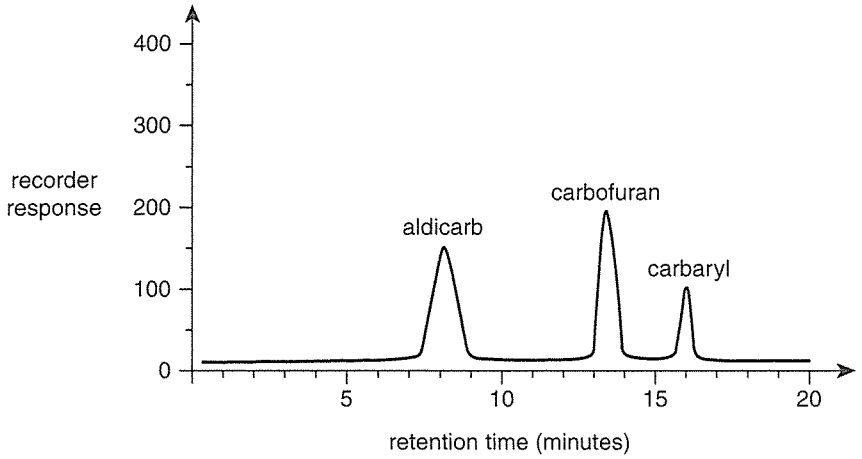
a. The high level of solubility of the molecule in water partly results from the formation of hydrogen bonds. One end of the structure of the pesticide molecule is shown in the diagram below.



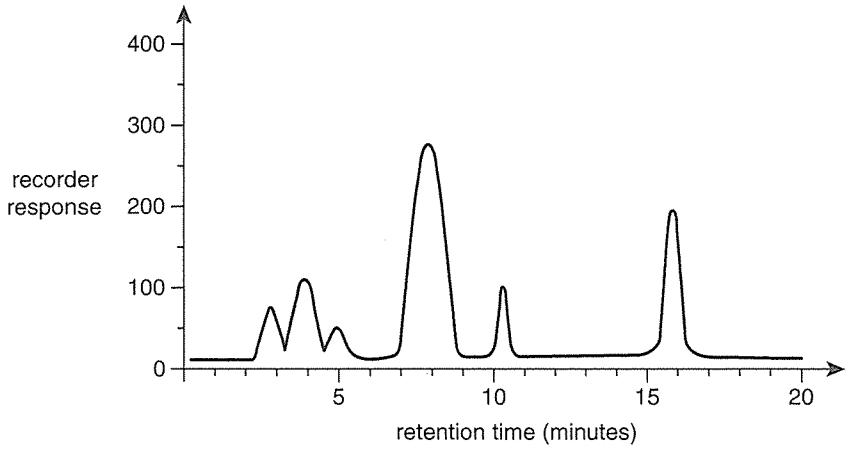
Show the formation of a hydrogen bond between the pesticide molecule and water by drawing the structural formula of a water molecule near the pesticide molecule. Label the hydrogen bond.

2 marks

b. High-performance liquid chromatography (HPLC) was used to analyse possible pesticide contamination of town drinking water from a river in an agricultural district. A standard solution of three pesticides was passed through a HPLC column, and the chromatogram below was obtained.



A sample of the town water was analysed by HPLC under identical conditions, resulting in the chromatogram shown below.



What conclusions can be made about the presence and levels of pesticide contamination by comparing the results of the two HPLC analyses? 2 marks

The sample contains aldicarb (Rt = 8 min) and carbaryl (Rt = 16 min) but not carbofuran (Rt = 13.5 min)

There is about 2x as much aldicarb as in the standard and 2x as much carbaryl as in the standard.

c. In a separate HPLC analysis, a water sample was taken from a different location and the areas under certain peaks in the resulting chromatograms were calculated.

Chromatogram peaks	Peak area
standard solution of aldicarb (5.0 mg L^{-1})	3792 units
aldicarb peak in water sample	458 units

Determine the molarity (M) of aldicarb in the water sample. 2 marks

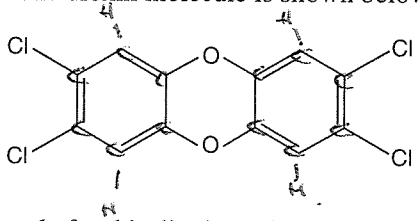
aldicarb in sample = $\frac{458}{3792} \times 5.0$

$= 0.60 \text{ mg L}^{-1}$

$0.60 \text{ mg/L} = 0.00060 \text{ g/L}$

$n = \frac{0.00060}{190.1} = 3.2 \times 10^{-6} \text{ M}$.

d. In addition to organic pesticides, other organic contaminants may be found in waterways. Dioxins are a class of persistent organic pollutant. They are difficult to remove from the environment. The structure of one dioxin molecule is shown below.



i. State the molecular formula for this dioxin molecule. 1 mark

$C_{12}H_4O_2Cl_4$

ii. State **one** source of dioxin contamination in waterways. 1 mark

iii. Suggest **one** reason why dioxins may accumulate in the fatty tissues of animals in a food chain. 1 mark

fats are non polar and so is aldicarb.
⇒ will dissolve in a non polar solvent (ie fatty tissue)

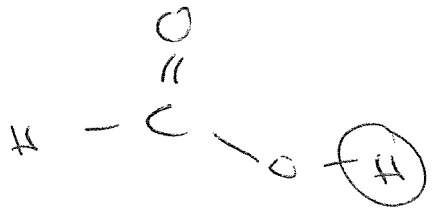
Question 4 (10 marks)

Methanoic acid (HCOOH) is a monoprotic weak acid.

a. **i.** Explain the meaning of the term 'weak acid'. 1 mark

One that does not fully ionise in water / aqueous solution.

ii. Draw the structure of the methanoic acid molecule, and circle the one acidic hydrogen atom. 2 marks



b. In a volumetric analysis to determine the concentration of a methanoic acid solution, 10.0 mL of the acid was diluted to a total volume of 250.0 mL in a standard flask. 20.00 mL aliquots of this diluted acid solution were separately titrated with a standardised 0.100 M solution of sodium hydroxide (NaOH). The average volume to reach the endpoint was 19.75 mL.

i. Methyl orange indicator was used in the titration.

What is the purpose of the indicator? 1 mark

To identify the equivalence point as closely as possible.

ii. Write a balanced equation for the titration reaction. 2 marks

$HCOOH(aq) + NaOH(aq) \rightarrow NaHCOO(aq) + H_2O(l)$

iii. Calculate the concentration of the methanoic acid in the original 10.0 mL sample. 3 marks

$n(NaOH) = cV = 0.100 \times 0.01975 = 0.001975$ mol.

$= n(HCOOH)$ $[HCOOH] = \frac{n}{V} = \frac{0.001975}{0.02000} = 0.09875$

or $c_2 = \frac{c_1 V_1}{V_2} = \frac{0.100 \times 19.75}{20.00} = 0.09875$ M.

then $c(\text{original}) = \frac{250}{10.0} \times 0.09875 = 2.47$ M

iv. If the titration is conducted at 25°C, what is the expected pH of the solution in the titration flask at the equivalence point of the titration? Indicate your answer by circling **one** of the options given below. 1 mark

less than 7 *exactly 7* *more than 7*

b/c $HCOO^-$ a weak base, is in the product solution at equivalence pt.

Question 5 (8 marks)

a. Water can act as both an acid and a base. Pure water has a very low, but measurable, electrical conductivity. At 25°C the pH of pure water is 7. The ionic product of water (K_w) varies with temperature as shown in the table below.

Temperature (°C)	0	15	35	55
K_w	1.14×10^{-15}	4.51×10^{-15}	2.09×10^{-14}	7.29×10^{-14}

i. Why does pure water conduct electricity, and why is this conductivity extremely low? Include a balanced chemical equation in your response. 3 marks

Water self ionises: $2H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$
⇒ there is a very low concentration of these ions in an equilibrium solution.
@ 25°C $[H_3O^+]$ and $[OH^-] = 10^{-7}$ M.
⇒ very low conductivity.

ii. What is the pH of pure water at 15°C? 2 marks

$[H_3O^+] = \sqrt{4.51 \times 10^{-15}} = 6.715 \times 10^{-8}$ M
⇒ $pH = -\log 6.715 \times 10^{-8} = 7.17$.

iii. What is the hydroxide ion concentration in pure water at 55°C? 1 mark

$[OH^-] = \sqrt{7.29 \times 10^{-14}} = 2.70 \times 10^{-7}$ M.

b. In addition to acting as both acid and base, water can also act as both oxidant and reductant.

i. Consider the reaction below.

$$Mg(s) + 2H_2O(l) \rightarrow Mg(OH)_2(aq) + H_2(g)$$

How is water acting in the reaction represented by the equation shown? Indicate your response by circling **one or more** of the four terms given below. 1 mark

acid *base* *reductant* *oxidant*

ii. Water may appear in the equation for a redox reaction but may not be the oxidant or reductant. One such reaction is represented by the unbalanced equation shown below.

$$Cr_2O_7^{2-}(aq) + H^+(aq) + I^-(aq) \rightarrow Cr^{3+}(aq) + I_2(l) + H_2O(l)$$

Write the balanced half-equation for the reduction process occurring in this reaction. 1 mark

$Cr_2O_7^{2-} + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$

END OF QUESTION AND ANSWER BOOKLET