Year 11
Semester Two
Examination 2022
Question/Answer booklet
Booklet 1

CHURCHLANDS SENIOR HIGH SCHOOL

ATAR CHEMISTRY UNITS 1 & 2

Section One. Multiple Choice. (25 marks)
Section Two. Short answers (78 marks)

Name: _____

Teacher: (circle your teacher's name)

COX ELIAS HARVEY POLAND SMITHIES

TIME ALLOWED FOR THIS PAPER
Reading time before commencing work: Ten minutes
Working time for the paper: Three hours

MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

To be provided by the supervisor:
Booklet 1 This Question/Answer Booklet
Booklet 2 Extended answer booklet
Multiple-choice Answer Sheet
Chemistry Data Book

To be provided by the candidate:
Standard items: pens, pencils, eraser or correction fluid, ruler, highlighter.

Special items: calculators satisfying the conditions set by the SCSA for this subject.

IMPORTANT NOTE TO CANDIDATES
No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam	
Section One: Multiple-choice	25	25	50	25	25	
Section Two: Short answer	10	10	60	78	35	
Section Three: Extended answer	5	5	70	86	40	
				Total	100	
Final percentage $\frac{\quad}{25} \times 25 + \frac{\quad}{78} \times 35 + \frac{\quad}{86} \times 40 =$					%	

Instructions to candidates

1. Answer the questions according to the following instructions.

   Section One: Answer all questions on the separate Multiple-choice Answer Sheet provided. For each question shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

   Sections Two and Three: Write your answers in this Question/Answer Booklet.

2. When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

3. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

4. Spare pages are included at the end of booklet 2. They can be used for planning your responses and/or as additional space if required to continue an answer.
   - Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
   - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

5. The Chemistry Data Book is **not** handed in with your Question/Answer Booklet.

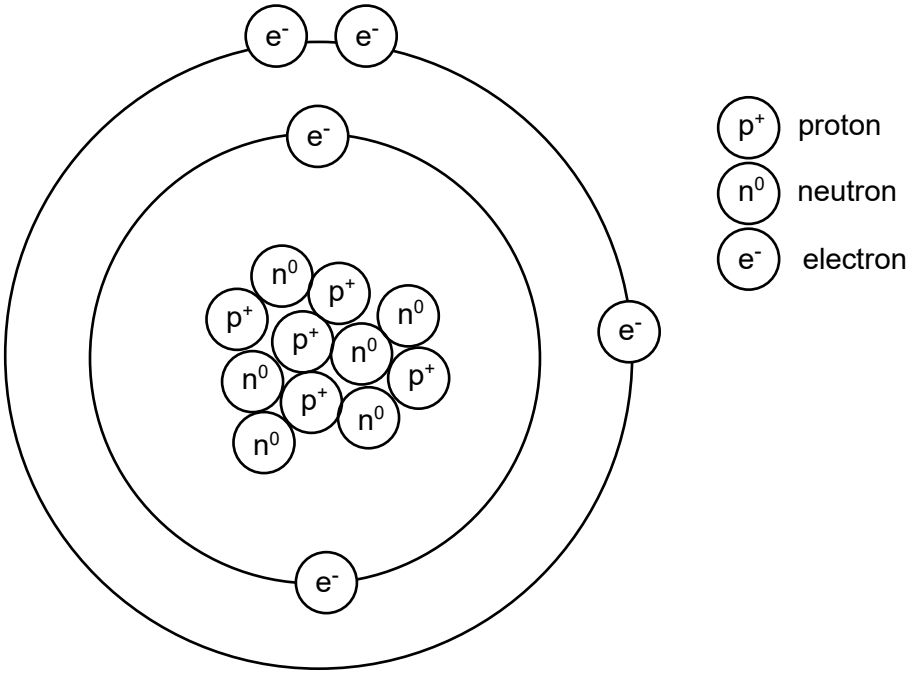
SEE NEXT PAGE

Section One: Multiple-choice **25% (25 marks)**

This section has **25** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 50 minutes.

1. Consider the diagram of the following atom.



Select the symbol below that can be used to represent this atom.

(a) $^{6}_{5}\mathrm{B}$
(b) $^{11}_{6}\mathrm{C}$
(c) $^{11}_{5}\mathrm{B}$
(d) $^{5}_{11}\mathrm{Na}$

2. The name of the compound with formula $Fe(NO_3)_3$ is

(a) iron nitrate.
(b) iron trinitrate.
(c) iron(II) nitrate.
(d) iron(III) nitrate.

3. Which of the following molecules is linear in shape, and exhibits dispersion forces as its only type of intermolecular force?

(a) SO_2
(b) CS_2
(c) HBr
(d) NO

4. Which of the following correctly shows the balanced ionic equation for the reaction between aluminium metal and sulfuric acid?

(a) $Al(s) + 2\ H^+(aq) \rightarrow Al^{2+}(aq) + H_2(g)$
(b) $2\ Al(s) + 3\ H_2^+(aq) \rightarrow Al_2^{3+}(aq) + 3\ H_2(g)$
(c) $2\ Al(s) + 6\ H^+(aq) \rightarrow 2\ Al^{3+}(aq) + 3\ H_2(g)$
(d) $2\ Al(s) + 6\ H^+(aq) + 3\ SO_4^{2-}(aq) \rightarrow 2\ Al^{3+}(aq) + 3\ SO_4^{2-}(aq) + 3\ H_2(g)$

5. Which element is made up of atoms with the same number of valence electrons as rubidium, but its valence electrons reside in the second energy level when in the ground state?

(a) Lithium
(b) Sodium
(c) Strontium
(d) Cesium

6. A student incorrectly named an organic compound '1,2-dibromo-3-ethylbutane'. The correct IUPAC name of this compound is

(a) 3-ethyl-1,2-dibromobutane.
(b) 1,2-dibromo-3-methylpentane.
(c) 2-ethyl-3,4-dibromobutane.
(d) 3-methyl-1,2-dibromopentane.

7. Which of the following temperatures cannot exist?

(a) 0 K
(b) 0 °C
(c) -273.15 K
(d) -273.15 °C

8. When compared to an uncatalysed reaction, a catalysed reaction pathway will have a lower enthalpy value for the

(a) reactants only.
(b) products only.
(c) reactants and products.
(d) transition state.

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Questions 9, 10 and 11 refer to the following information.

Consider the unbalanced chemical equation below, representing the complete combustion of propene.

$$\_\_\_\ C_3H_6(g) + \_\_\_\ O_2(g) \rightarrow \_\_\_\ CO_2(g) + \_\_\_\ H_2O(g)$$

9. The number of moles of oxygen required for the complete combustion of propene can be represented as

(a) $n(O_2) = \frac{9}{2} \times n(C_3H_6)$

(b) $n(O_2) = \frac{2}{9} \times n(C_3H_6)$

(c) $n(O_2) = \frac{1}{4} \times n(C_3H_6)$

(d) $n(O_2) = \frac{4}{1} \times n(C_3H_6)$

10. In this reaction, the energy required to break the bonds in the reactants would be

(a) small.
(b) large.
(c) smaller than the energy released when the bonds in the products form.
(d) larger than the energy released when the bonds in the products form.

11. If the combustion of propene occurred in a limited oxygen environment, this would result in

(a) the Law of Conservation of Mass not being upheld.
(b) the sign of the heat of reaction changing.
(c) the formation of more toxic gases.
(d) net zero carbon emissions.

12. Which of the following statements cannot be supported by the Arrhenius theory of acids and bases?

(a) Hydrochloric acid is a strong acid.
(b) Ethanoic acid is a weak acid.
(c) Sodium hydroxide is a strong base.
(d) Calcium carbonate is a weak base.

13. When comparing the atomic radii of a sulfur atom and a chlorine atom.
The atomic radius of chlorine is

(a) larger because chlorine has more protons and electrons.
(b) smaller because there is increased shielding from the electrons.
(c) larger because the electrons are held more loosely.
(d) smaller because the nucleus has a greater positive charge.

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14. What is the pH of a 0.023 mol L^{-1} solution of calcium hydroxide solution at 25^0C?

(a) 1.64
(b) 12.66
(c) 12.36
(d) 13.66

15. Which of the following is a common property of all metals?

(a) Solid at room temperature.
(b) Hard when solid.
(c) Thermal insulator.
(d) Electrical conductor.

Questions 16 and 17 refer to the following information.

A laboratory technician developed a method which used thin layer chromatography (TLC) to identify many common food colourings added to food.

The technician used reversed-phase TLC, where a non-polar stationary phase was used in conjunction with a polar mobile phase. The solvent front was allowed to progress for a distance of 8.00 cm from the origin, to ensure optimal separation.

A selection of the data obtained by the chemist is shown in the table below.

Food additive E number	Food colour name	Retardation factor, R_f (cm)
E102	Tartrazine	0.64
E110	Sunset yellow	0.36
E123	Amaranth	0.55
E129	Allura red	0.28

16. Which food colouring is likely to be the most polar?

(a) Tartrazine
(b) Sunset yellow
(c) Amaranth
(d) Allura red

17. What distance would the colour ‘Sunset yellow’ have moved from the origin on the TLC plate?

(a) 0.36 cm
(b) 2.88 cm
(c) 5.12 cm
(d) 22.22 cm

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18. Which of the coefficients below would correctly balance the following chemical equation?

$$\_\_\_\ Cr_2S_3(s) + \_\_\_\ HCl(aq) \rightarrow \_\_\_\ CrCl_3(aq) + \_\_\_\ H_2S(g)$$

(a) 1, 6, 2, 3
(b) 1, 3, 2, 6
(c) 2, 6, 2, 3
(d) 3, 9, 6, 3

19. The relative atomic mass of an element

(a) is equivalent to the mass of the most abundant isotope.
(b) is the average relative mass of an atom in a naturally occurring mixture of isotopes.
(c) is a ratio compared to 1/12th the mass of an atom of carbon-12.
(d) has the units 'grams per mole'.

20. The formula of

(a) zinc sulfide is $ZnSO_3$.
(b) ammonia is NH_4^+.
(c) barium iodide is BaI_2.
(d) sulfurous acid is H_2SO_2.

21. The pH of a solution is a measure of the concentration of hydrogen ions. Therefore calculating the pH of a solution is only meaningful if the solution is

(a) acidic.
(b) basic.
(c) neutral.
(d) aqueous.

22. When the volume of a gas is decreased, at constant temperature, the pressure of the gas will increase. This is because

(a) the particles will collide with the walls of the container with more force.
(b) the particles will collide with the walls of the container with greater speed.
(c) the particles will collide with the walls of the container with greater frequency.
(d) all of the above are true.

23. Which of the following combinations of 0.1 mol L^{-1} solutions would **not** form a precipitate upon mixing?

(a) Na_2SO_4, KCl, $Ba(OH)_2$
(b) NH_4Cl, KOH, Na_2SO_4
(c) NaCl, $MgSO_4$, $AgNO_3$
(d) $MgCl_2$, $(NH_4)_2SO_4$, KOH

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Questions 24 and 25 refer to the following information.

A student decides to investigate the chemical reaction between solid barium hydroxide, $Ba(OH)_2$, and solutions containing various acids.

The student carefully weighed equal masses of $Ba(OH)_2(s)$ pellets into four separate beakers, labelled A, B, C and D. They then added 50 mL of acid to each beaker, and recorded how long it took for all the pellets to dissolve.

The set-up of the investigation is summarised in the table below.

	Beaker A	Beaker B	Beaker C	Beaker D
Initial contents of beaker	$Mg(OH)_2(s)$	$Mg(OH)_2(s)$	$Mg(OH)_2(s)$	$Mg(OH)_2(s)$
50 mL of acid solution added	+ 0.25 mol L^{-1} HCl (aq)	+ 0.50 mol L^{-1} HCl (aq)	+ 0.25 mol L^{-1} $H_2SO_4(aq)$	+ 0.50 mol L^{-1} H_2SO_4 (aq)
Time taken for solid to dissolve	?	?	?	?

24. Which of the following correctly shows the balanced ionic equation for the reactions occurring in this investigation?

(a) $2\ H^+(aq) + Mg(OH)_2(s) \rightarrow Mg^{2+}(aq) + 2\ H_2O(l)$
(b) $H^+(aq) + Mg(OH)_2(s) \rightarrow MgOH(aq) + H_2O(l)$
(c) $H^+(aq) + OH^-(s) \rightarrow H_2O(l)$
(d) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

25. For which two (2) beakers would the student record the most similar times?

(a) A and C
(b) B and C
(c) B and D
(d) C and D

End of Section One

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Section Two: Short answer **35% (78 marks)**

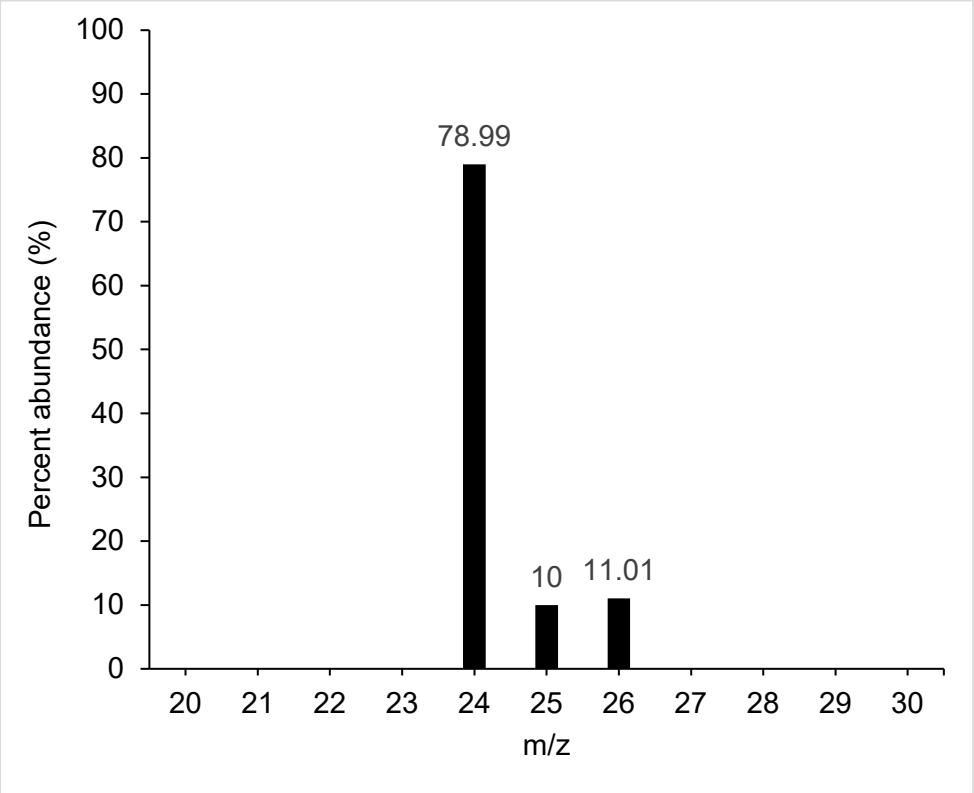
This section has 10 questions. Answer **all** questions. Write your answers in the spaces provided.

Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

Suggested working time: 60 minutes.

Question 26 **(6 marks)**

A pure sample of an element was analysed in a mass spectrometer and the following graphical data was obtained.



(a) Calculate the relative atomic mass of this element, and thus state its identity. (2 marks)

The subatomic particle arrangement of several species has been partially summarised in the table below.

Species	Number of protons	Number of neutrons	Electron configuration	Mass number	Overall charge
W	11			24	0
X		14	2, 8		+2
Y	17	20			-1

(b) Complete the table above. (3 marks)

(c) Which of the species in the table(W, X or Y) represents particles of the same element that was analysed by mass spectrometry in part (a)? (1 mark)

_____

Question 27 **(9 marks)**

Complete the following table by;

- drawing an electron dot diagram for each substance,
- predicting whether, when mixed with water, the compound would form a solution capable of conducting electricity.

substance	Electron Dot diagram	Would dissolving in water increase conductivity of water sample ('yes' or 'no')
O_2	(2 marks)	(1 mark)
HNO_3	(2 marks)	(1 mark)
$Al_2(SO_4)_3$	(2 marks)	(1 mark)

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Question 28 **(7 marks)**

Catalytic converters must be fitted on all vehicles as a legal requirement.

The chemical reactions that occur within catalytic converters are catalysed by precious metals such as platinum, palladium and rhodium.

The design of the catalytic converter has changed greatly in the last decade, due to advances in the use of nanomaterials. Nanoparticles of precious metals are now incorporated in place of the bulk material formerly used. This has reduced the amount of precious metals used in catalytic converters by 70-90%.

(a) State the function of a catalytic converter. (1 mark)

(b) Explain why the use of nanoparticles has greatly reduced the amount of precious metals used to construct a catalytic converter. (3 marks)

Currently, palladium costs approximately $110 per gram.

(c) Calculate the number of palladium atoms you could purchase for $1. (3 marks)

Question 29 **(9 marks)**

Consider the information in the table below, regarding the vapour pressures of three common liquids.

	Vapour pressure at 20 °C (kPa)
Water	2.34
Ethanol	5.83
Hexane	17.6

(a) Explain, in terms of intermolecular forces, why the vapour pressure of hexane is much higher than the other two liquids. (3 marks)

(b) Which of these liquids has the highest boiling point? Justify your answer using the information from the table above. . (3 marks)

(c) Explain, in terms of the kinetic theory, why the vapour pressure of water increases with increasing temperature. (3 marks)

Question 30 **(8 marks)**

High performance liquid chromatography (HPLC) can be used to identify which 'acidulants' (compounds that give a sour taste) are present in food and drink samples.

The information below relates to the HPLC data collected from the analysis of several common acidulants.

Sample preparation: filtration
Non-Polar Stationary phase: polymer-based matrix
Polar Mobile phase: 0.0035 mol L^{-1} $H_2SO_4(aq)$
Flow rate: 0.6 mL min^{-1}

Acidulant	Retention time (min)
Oxalic acid	6.5
Citric acid	8.0
Tartaric acid	8.5
Malic acid	9.5
Sulfur dioxide	10.5
Succinic acid	12
Lactic acid	14
Acetic acid	17

(a) Which acidulant is likely to be the most polar? Justify your answer, making reference to the role of intermolecular forces. (4 marks)

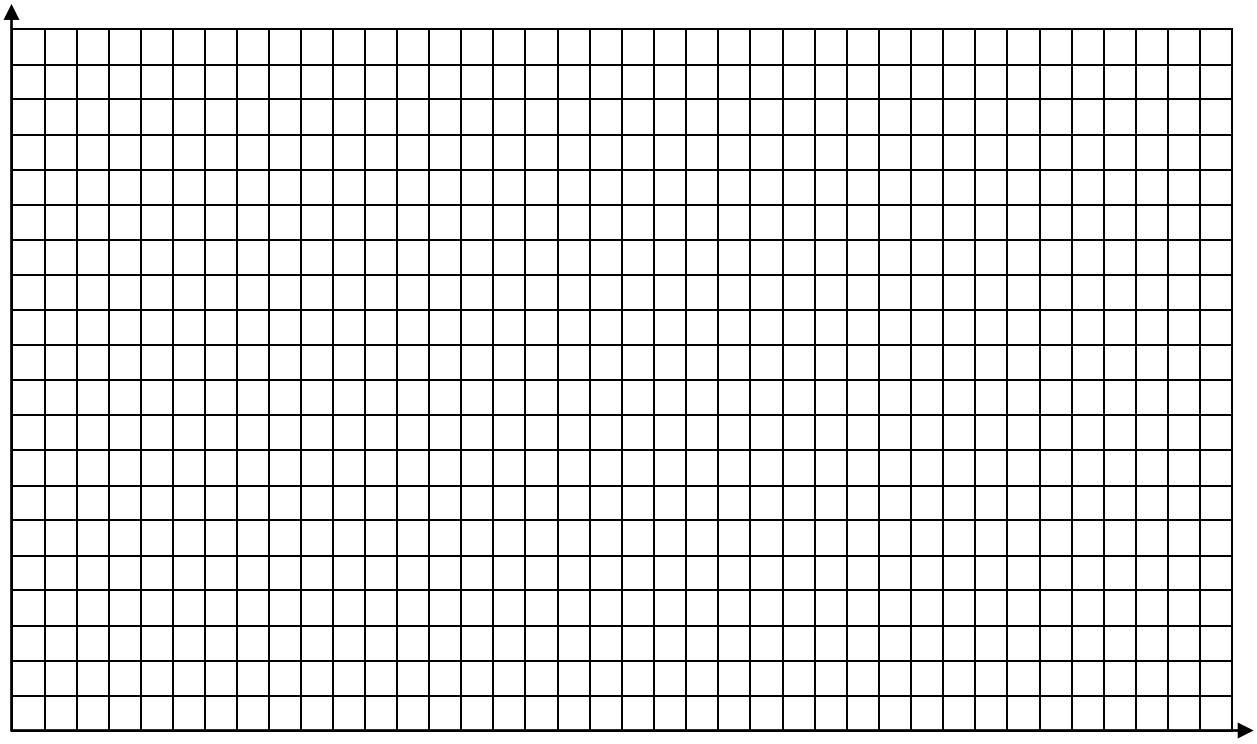
A particular white wine was analysed by HPLC. Assume the conditions used for this analysis were identical to those stated on the previous page.

The wine was known to contain;

acidulants	**Absorbance**
citric acid	12
tartaric acid	18
sulfur dioxide	15
succinic acid	3

(b) On the grid below, sketch the expected chromatogram for the white wine sample.

Label both axes appropriately. (4 marks)



Question 31 **(8 marks)**

A beaker contained a powdered mixture consisting of iron filings, Fe(s), sand, $SiO_2(s)$ and nickel chloride, $NiCl_2(s)$.

The iron filings were separated first, using a magnet. The filings were melted down and cooled to form a lump of solid iron.

(a) Explain, in terms of structure and bonding, why this lump of iron now has the ability to be extruded /drawn into a paperclip. (3 marks)

Water was then added to the remaining two solids, resulting in all the nickel chloride dissolving.

(b) Explain, in terms of structure and bonding, why the sand did not dissolve. (2 marks)

(c) Name a separation technique by which the sand could now be removed from the mixture. (1 mark)

The remaining mixture was a solution of nickel chloride, $NiCl_2(aq)$.

(d) Name a separation technique that would allow the solid nickel chloride to be recovered. (1 mark)

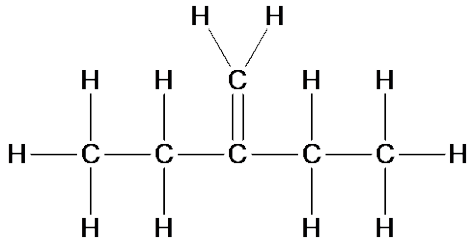
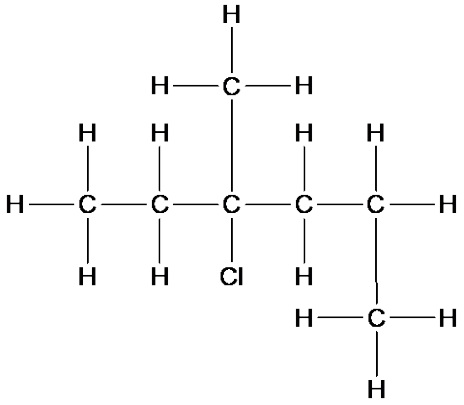
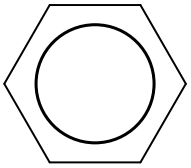
(e) Identify the physical property of the two remaining compounds in the nickel chloride solution that makes this separation possible. (1 mark)

Question 32 **(9 marks)**

Consider the three organic reactions which are partially summarised in the table below.

Complete this table by;

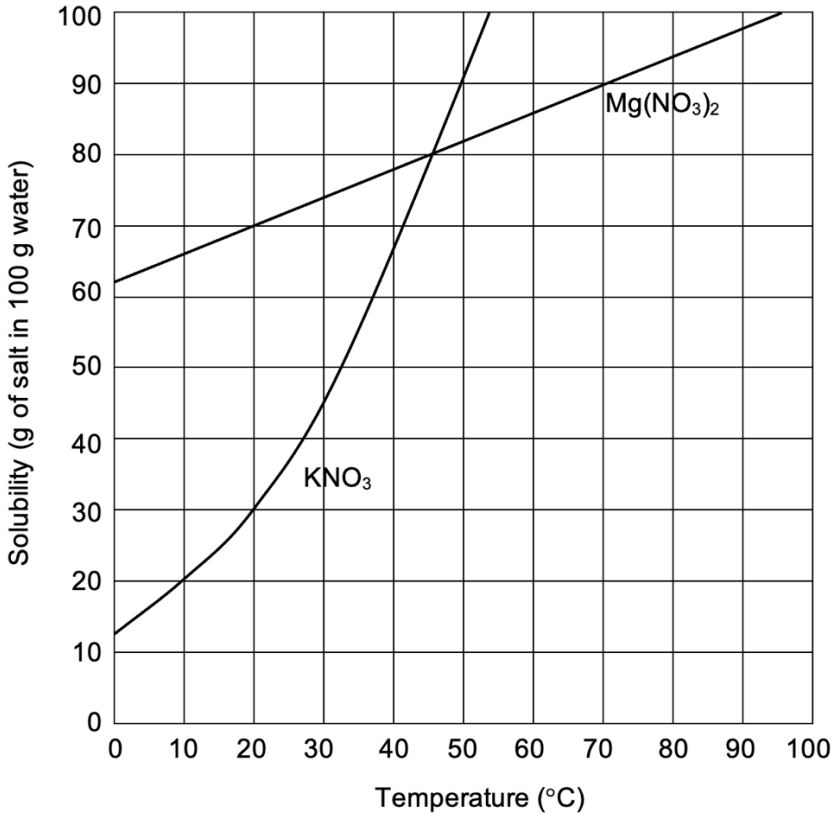
- drawing the structural formula for any missing organic reactants and products, and
- stating the IUPAC name for any missing organic reactants and products.

Starting organic **reactant**	Reaction	Final organic **product**
	Reactant shaken with bromine water, $Br_2(aq)$	Structural formula: (2 marks) IUPAC name: (1 mark)
Structural formula: (2 marks) IUPAC name: (1 mark)	Reactant shaken with chlorine water, $Cl_2(aq)$, in the presence of UV light	
	Reactant shaken with bromine water, $Br_2(aq)$, in the presence of $AlBr_3(s)$ Catalyst	Structural formula: (2 marks) IUPAC name: (1 mark)

SEE NEXT PAGE

Question 33 **(7 marks)**

Consider the information presented in the solubility graph below.



A student measured 210 g of water into a beaker. They then weighed out 125 g of $KNO_3(s)$ and added this to the beaker. The solution was warmed to 50 °C to ensure that all the $KNO_3(s)$ had dissolved. Then the solution was gently cooled back down to 30 °C.

The resulting solution is now classified as 'supersaturated'.

(a) Define a 'supersaturated' solution. (1 mark)

Supersaturated solutions are generally very unstable. A speck of dirt fell into the supersaturated solution described above.

(b) Calculate the mass of $KNO_3(s)$ crystals that would form. Show all workings. (3 marks)

The student then mixed the same mass of $Mg(NO_3)_2(s)$ with the same mass of water (i.e. they dissolved 125 g of $Mg(NO_3)_2(s)$ into 210 g of water), and adjusted the temperature to 30 °C.

(c) Classify this solution as 'unsaturated', 'saturated' or 'supersaturated'. (1 mark)

_____

Using two clean beakers, the student prepared a 0.1 mol L^{-1} solution of $KNO_3(aq)$ and a 0.1 mol L^{-1} solution of $Mg(NO_3)_2(aq)$. However, they forgot to label which beaker was which.

(d) Describe how the student could use a flame test to distinguish these solutions. (2 marks)

_____

_____

_____

_____

_____

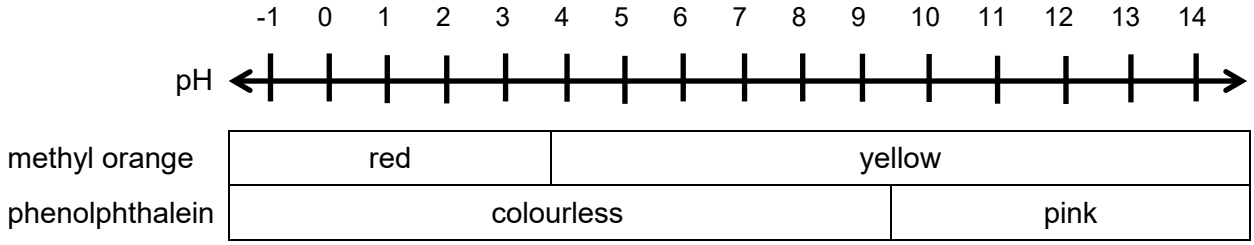
Question 34 **(8 marks)**

Three beakers, labelled A, B and C, sat on a laboratory bench. The liquids in the beakers were known to be;

0.5 mol L^{-1} KOH(aq) 0.5 mol L^{-1} HNO_3(aq) H_2O(l)

A student was asked to devise a method to identify the liquid in each beaker. After some research, the student decided that they could distinguish these liquids using the indicators methyl orange and phenolphthalein.

Some information about these indicators is provided below.



(a) Describe a method the student could use with these indicators to identify which liquid was in each beaker and expected observations. (2 marks)

Unfortunately, the student did not have access to these indicators in the laboratory. Therefore they devised an alternate method to identify the liquids, using a series of chemical tests.

About 10 mL of liquid from each beaker was placed into separate test tube, correspondingly labelled A, B and C. A small amount of powdered NH_4Cl(s) was added to each test tube, and the observations were recorded in the table below.

(b) Complete this table, by including the **distinguishing observation** for test tube C.(1 mark)

Test tube A	White powder dissolves
Test tube B	White powder dissolves
Test tube C	

SEE NEXT PAGE

(c) Write a balanced ionic equation for the reaction occurring in test tube C. (2 marks)

Fresh 10 mL samples of liquids A and B were then poured into two new test tubes. A small amount of powdered $MgCO_3(s)$ was added to each test tube, and the observations were recorded in the table below.

(d) Complete this table, by including the distinguishing observation for test tube A. (1 mark)

Test tube A	
Test tube B	No visible reaction

(e) Write a balanced ionic equation for the reaction occurring in test tube A. (2 marks)

Question 35 **(7 marks)**

The reaction that occurs in a petrol engine can be represented by the combustion of octane, as shown below.

$$2\ C_8H_{18}(l)\ +\ 25\ O_2(g)\ \rightarrow\ 18\ H_2O(g) +\ 16\ CO_2(g)\ +\ 10920\ kJ$$

A great deal of research is continuing in the automotive industry, to design vehicles that run on hydrogen or other biofuels.

The combustion reaction occurring in hydrogen fuelled vehicles is given below.

$$2\ H_2(g)\ +\ O_2(g)\ \rightarrow\ 2\ H_2O(l)\ +\ 564\ kJ$$

Assume a standard 60 L petrol tank can hold 48.18 kg of octane.

(a) Calculate the amount of energy that would be released in the combustion of one full tank of petrol. (3 marks)

(b) Calculate the volume of hydrogen gas, stored at STP, that would be required to produce this same amount of energy. (2 marks)

(c) Identify one (1) advantage and one (1) disadvantage of hydrogen powered vehicles. (2 marks)

Advantage	
Disadvantage	

End of Section Two

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Year 11
Semester Two
Examination 2022
Question/Answer booklet
Booklet 2

CHURCHLANDS SENIOR HIGH SCHOOL

ATAR CHEMISTRY UNITS 1 & 2

Student Name._____

Teacher: (circle your teacher's name)

COX ELIAS HARVEY POLAND SMITHIES

Section Three: Extended answer 40% (86 marks)

This section contains **five (5)** questions. You must answer **all** questions. Write your answers in the spaces provided below.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression. Lists or dot points are unlikely to gain full marks.

Final answers to calculations should be expressed to the appropriate number of significant figures.

Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

Suggested working time: 70 minutes

Question 36 **(15 marks)**

First Nations peoples have been using rock art as an important form of cultural expression for at least 65000 years. These artworks are traditionally painted using ochres, which are natural pigments and minerals.

The table below lists some of the compounds used to create the different colours seen in these artworks.

	Name and formula of mineral
Red, yellow, orange pigments	haematite, Fe_2O_3 goethite, FeOOH jarosite, $KFe_3(OH)_6(SO_4)_2$
White pigments	kaolinite, $Al_2Si_2O_5(OH)_4$ huntite, $CaMg_3(CO_3)_4$ gypsum, $CaSO_4.2H_2O$ calcite, $CaCO_3$
Black pigments	charcoal, C pyrolusite, MnO_2

These minerals are hard, but can be ground into a powder because they are brittle. The powder can then be mixed with water to form a paste. With the exception of charcoal, all the other minerals exhibit the same type of bonding.

(a) Identify the primary type of bonding present in these minerals (other than charcoal), and explain, in terms of structure and bonding, why they are **hard** and **brittle**. (5 marks)

Each of the red pigments obtain their colour from the presence of iron in the various minerals. The percentage by mass of iron is different in each of these minerals, as shown in the table below.

	Percentage by mass of iron (Fe)
haematite, Fe_2O_3	69.94 %
goethite, FeOOH	62.85 %
jarosite, $KFe_3(OH)_6(SO_4)_2$	?

Many examples of rock art in the Kimberley region display a characteristic ‘mulberry red’ colour. Chemical analyses have shown that this is due to the mineral jarosite, which is commonly found in Western Australia.

(b) Calculate the percentage by mass of iron in jarosite, and suggest a reason for the different shade of red produced by this mineral. (3 marks)

Chemists have also determined that the white pigment used in rock art in the Kimberley region commonly contains huntite. The main industrial use of the mineral huntite is as a flame retardant additive in the production of some plastics.

These flame retardant properties result from the endothermic decomposition of huntite, which occurs between 400-800 °C. This chemical equation for this reaction is given below.

$$Mg_3Ca(CO_3)_4(s) + 350\ kJ \rightarrow 3\ MgO(s) + CaO(s) + 4\ CO_2(g)$$

The flame retardant qualities arise from the endothermic nature of the reaction, which absorbs heat from the fire, as well as the production of carbon dioxide gas, which assists in extinguishing the flames.

During a routine safety test, 5.75 kg of a particular plastic was set alight, under carefully controlled conditions. The plastic contained 3.82% huntite by mass.

(c) Calculate the volume of $CO_2(g)$, measured at STP, that would be produced, if all the huntite underwent decomposition. State your answer to the appropriate number of significant figures. (6 marks)

(d) Calculate the quantity of heat that would have been absorbed. (1 mark)

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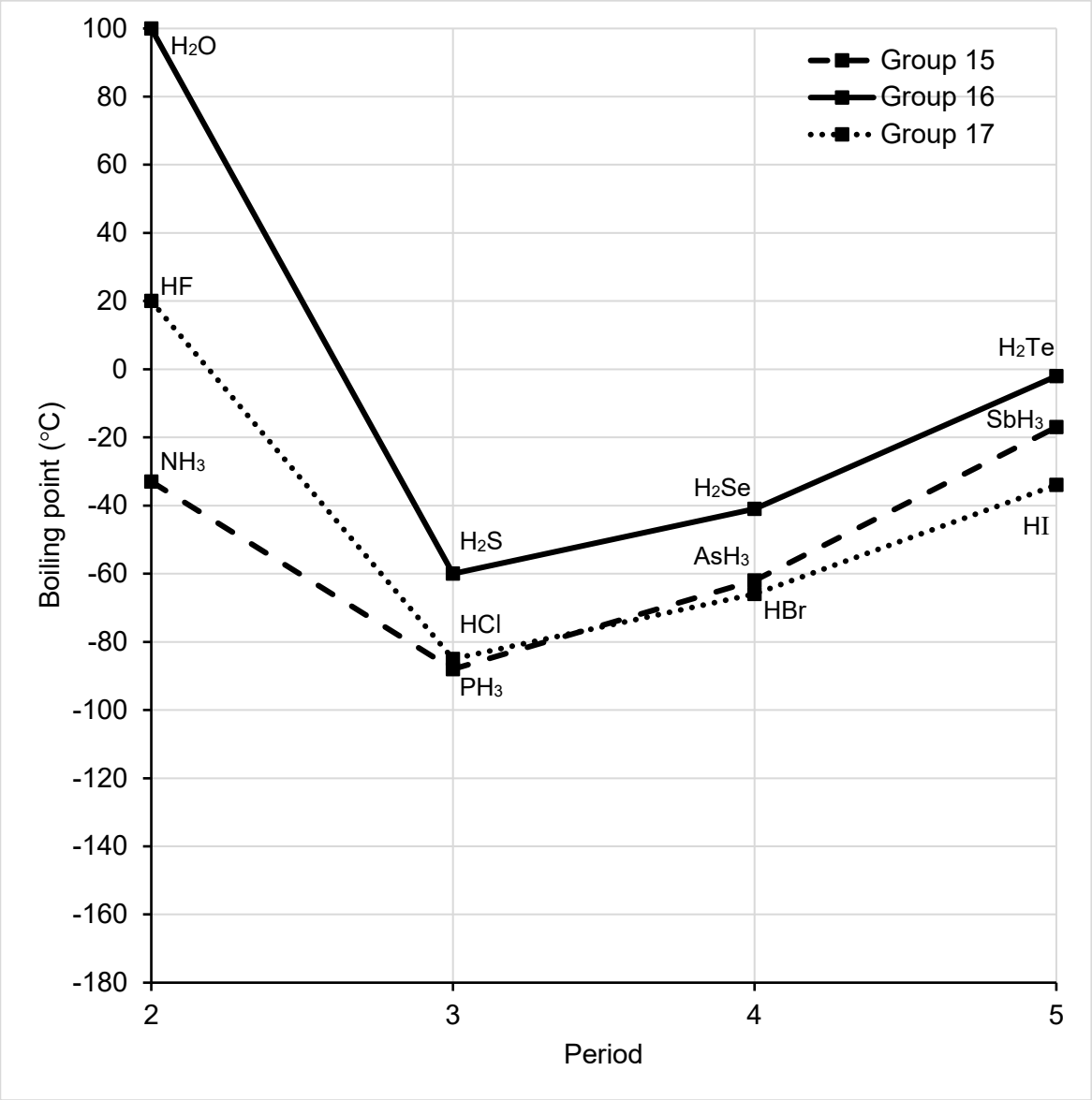
Question 37 **(16 marks)**

Consider the data presented in the graph below, regarding the boiling points of the Group 15, 16 and 17 hydrides.



(a) Identify the molecular shape of each of the following groups of hydrides. (2 marks)

Group 16 hydrides	
Group 17 hydrides	

Consider **only** the Group 17 hydrides. (HF, HCl, HBr, HI)

(b) State and explain the trend in electronegativity as you move down the Group 17 elements. (3 marks)

(c) Explain, using the concept of electronegativity, which of the Group 17 hydrides is the most polar. (2 marks)

Consider **only** the Group 16 hydrides. (H_2O, H_2S, H_2Se, H_2Te)

(d) Identify the hydride which exhibits the strongest dispersion forces, and explain why this occurs. (3 marks)

Consider the following data regarding the boiling points of the Group 14 hydrides.

	CH_4	SiH_4	GeH_4	SnH_4
Boiling point (°C)	-162	-112	-88	-52

(e) Plot this boiling point data on the graph on the page 30 . (1 mark)

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(f) Explain why the boiling points of H_2O, HF and NH_3 do **not** follow the same trend seen in the Group 14 hydrides. Support your answer with a diagram illustrating the predominant type of intermolecular interaction in NH_3. (5 marks)

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Question 38 **(14 marks)**

Consider the reaction between solutions of sodium hydrogencarbonate and calcium chloride, which can be represented by the chemical equation below.

$$2\ NaHCO_3(aq)\ +\ CaCl_2(aq)\ \rightarrow\ CaCO_3(s)\ +\ 2\ NaCl(aq)\ +\ H_2O(l)\ +\ CO_2(g)$$

This reaction occurs spontaneously at room temperature and has a fast reaction rate.

(a) Define activation energy, and suggest what assumption can be made regarding the magnitude of the activation energy for this reaction. (2 marks)

A chemistry student decided to study this reaction. They mixed small amounts of the two solutions in a beaker. The student noted that after a few seconds the beaker felt warmer.

(b) On the axes below, sketch an energy profile diagram for this reaction.
Label the following.
- the axes,
- Activation energy
- Enthalpy change. (4 marks)

The student then chose to investigate how the initial temperature of the reactant solutions affected the rate of reaction.

In order to do this, they warmed five separate samples of each $NaHCO_3(aq)$ and $CaCl_2(aq)$ to five different temperatures by placing them in a water bath. The water baths were set at temperatures of 20 °C, 30 °C, 40 °C, 50 °C and 60 °C.

Once the reactants had reached the desired temperature they were mixed together in a beaker, whilst data regarding the rate of reaction was recorded.

(c) Suggest two (2) ways that the rate of this reaction could be measured. (2 marks)

1.	
2.	

(d) List two (2) variables that should be controlled in order to ensure the data collected by the student is valid. (2 marks)

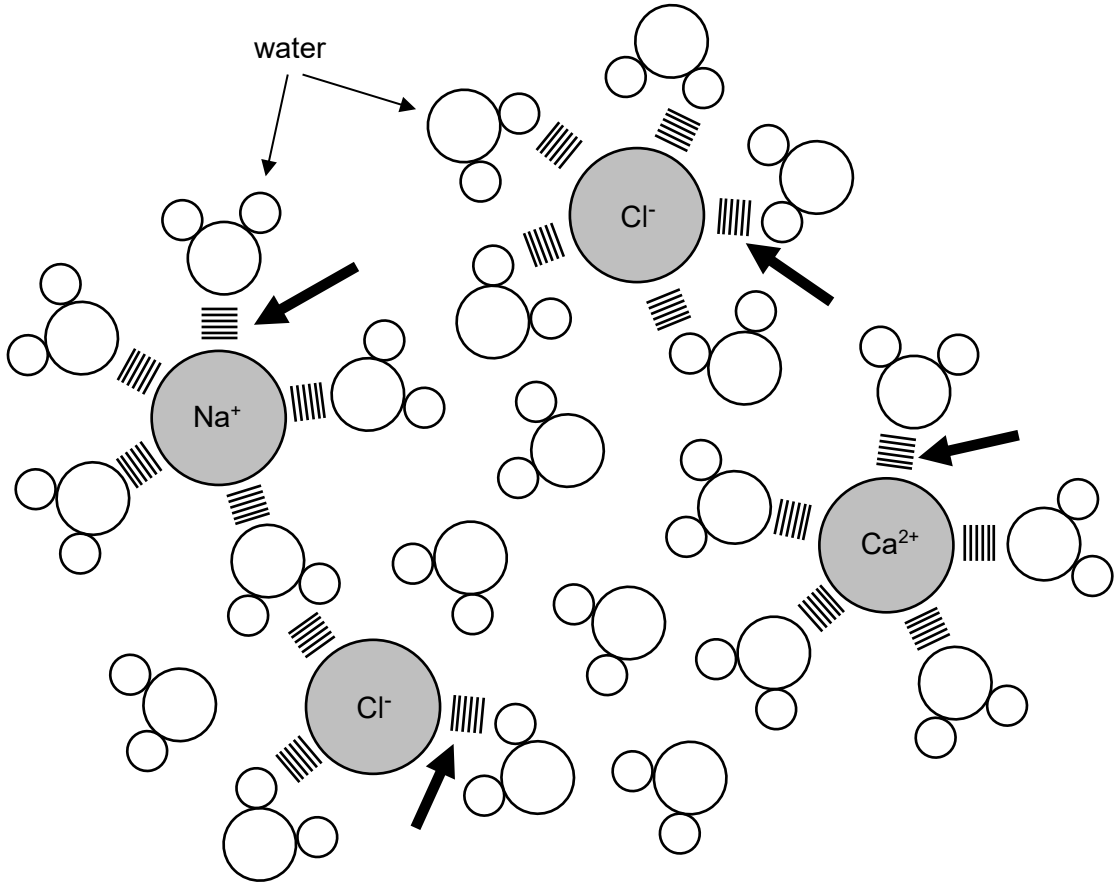
1.	
2.	

(e) Predict the likely outcome of this investigation, using collision theory to support your answer. (4 marks)

Question 39 **(27 marks)**

Approximately 97% of all Earth's water lies in the oceans. Seawater contains many different dissolved ions, the most abundant of which are chloride, $Cl^-(aq)$, sodium, $Na^+(aq)$, magnesium, $Mg^{2+}(aq)$, sulfate, $SO_4^{2-}(aq)$, calcium, $Ca^{2+}(aq)$ and potassium, $K^+(aq)$.

The diagram below includes some of the components of seawater.



(a) (i) Name the type of forces indicated by the arrows (➡) on the diagram. (1 mark)

_____

(ii) Explain how these forces form. (3 marks)

_____

_____

_____

_____

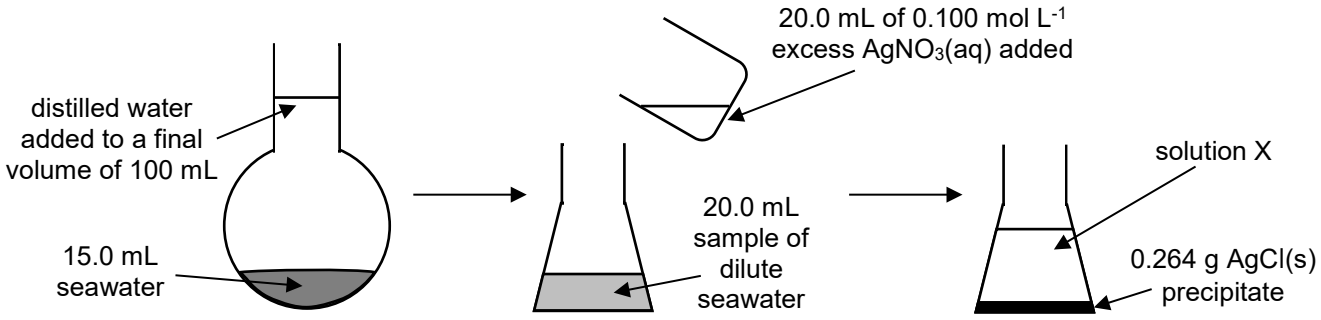
_____

_____

_____

A chemist collected a sample of seawater from Cottesloe beach in order to determine its chloride, $Cl^-(aq)$, concentration.
They transferred 15.0 mL of seawater to a flask and added distilled water to make the final volume up to 100 mL. The chemist then took a 20.0 mL portion of the dilute seawater and placed it in a conical flask. To this, they added 20.0 mL of 0.100 mol L^{-1} silver nitrate, $AgNO_3(aq)$, solution. Excess silver nitrate was added, to ensure all the chloride ions would be precipitated.

The mass of solid silver chloride, AgCl(s), was determined to be 0.264 g.



(b) Calculate the concentration of chloride ions in seawater, in moles per litre. (5 marks)

(c) Calculate the concentration of silver ions in solution X (see diagram). (3 marks)

(d) A sample of sea water from the Dead sea (know to have a higher salt concentration than normal sea water) was obtained by the chemist. The concentration of the Dead Sea water is know to be 21.2 $molL^{-1}$ NaCl.

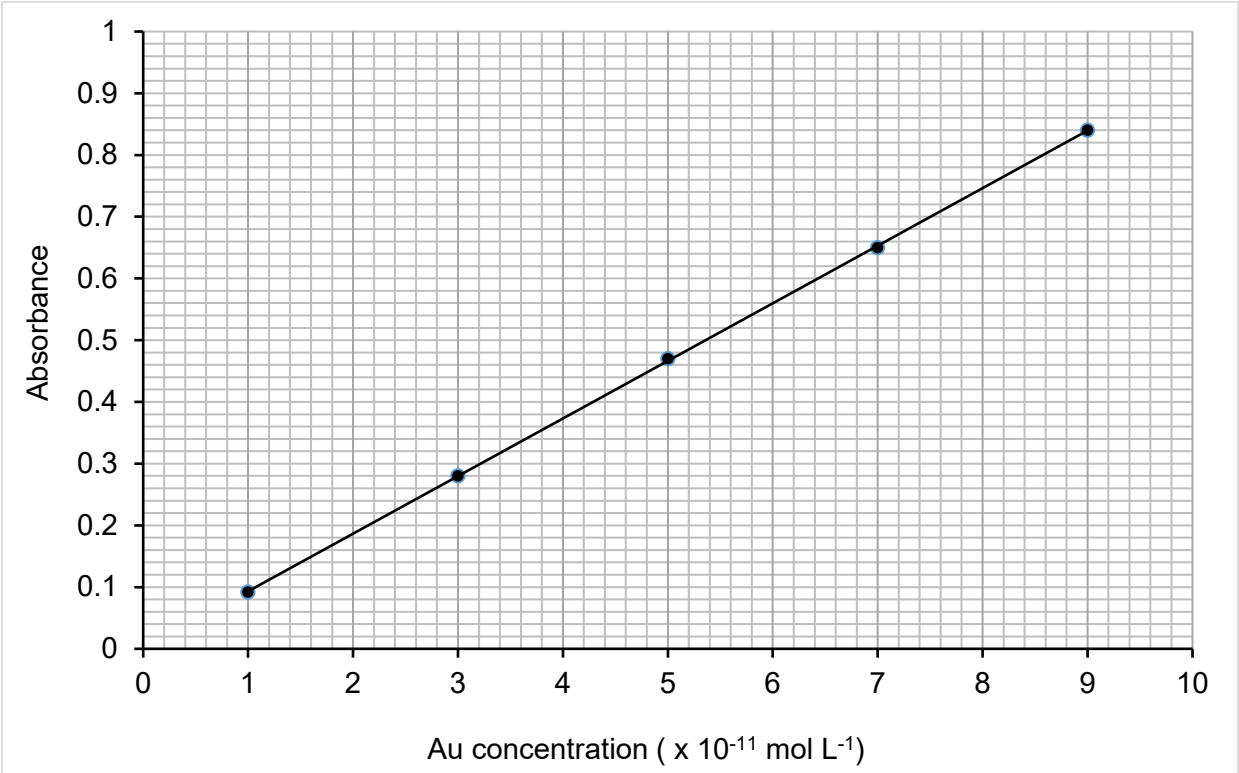
The student took a 25.0 mL sample of the sea water and added 150.0mL of 3.20 $molL^{-1}$ $AgNO_3$ solution to the sample.

(i) Did the student add a large enough volume of silver nitrate solution to precipitate out all of the chloride ions present in the sample. (show your working) (4 marks)

(ii) Calculate the mass of the silver chloride solid that would have formed in the above reaction. (2 marks)

Seawater also contains very small amounts of gold. In order to determine the gold concentration, the chemist analysed a further sample of seawater by atomic absorption spectrometry (AAS).

The results of the analysis were compared to the calibration curve below.



(e) Explain, with reference to the process of AAS, why a higher concentration of gold results in a higher absorbance reading. (3 marks)

Trace amounts of silver are also found in sea water.

(f) Give a reason that the presence of silver in seawater would **not** affect the AAS absorbance reading. (1 mark)

The chemist recorded the absorbance of the seawater sample to be 0.50. The density of seawater was also determined to be 1.0236 kg L^{-1}.

(g) Calculate the concentration of gold in seawater, in parts per million. (5 marks)

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Question 40 **(14 marks)**

Ethanol, C_2H_5OH, is an extremely versatile and important substance. Its primary use is as a fuel, but it also has a wide range of applications as a solvent and antiseptic, in addition to its use in alcoholic beverages.

Ethanol is manufactured industrially by the reaction of ethene gas and water vapour, in the presence of a phosphoric acid catalyst. This reaction is performed at 300 °C, which results in gaseous ethanol forming. This reaction produces 45 kJ of heat per mole of ethene.

(a) Write a balanced thermochemical equation for this reaction. Use full structural formulae for any organic substances and include state symbols. (5 marks)

(b) Name the type of reaction occurring. (1 mark)

(c) Explain how this reaction conforms to the Law of Conservation of Energy, despite producing heat. (3 marks)

This reaction is carried out at a high pressure of 6000-7000 kPa.

(d) Explain, in terms of the collision theory, how this would increase the rate of this reaction. (2 marks)

(e) Explain, in terms of the collision theory, the function of the phosphoric acid catalyst in this reaction. (3 marks)

End of questions

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Question number(s): ……

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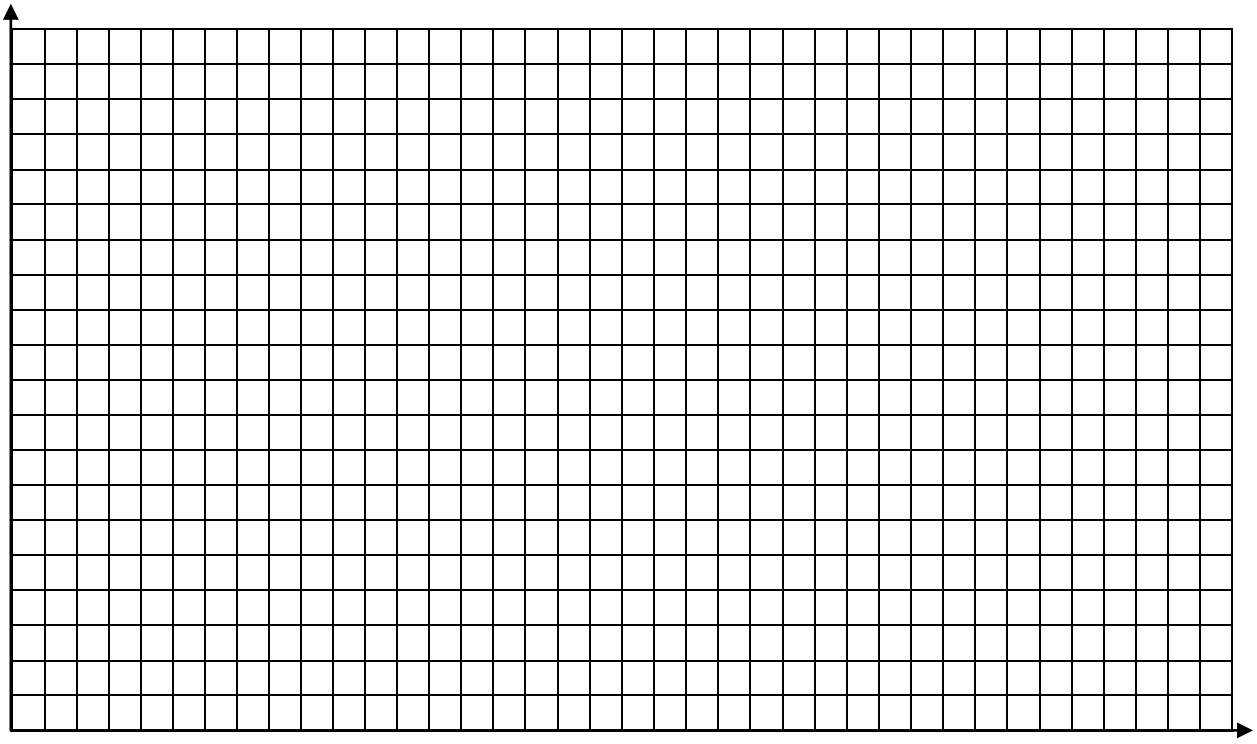
Question 30 (b)



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Question 38 (b)

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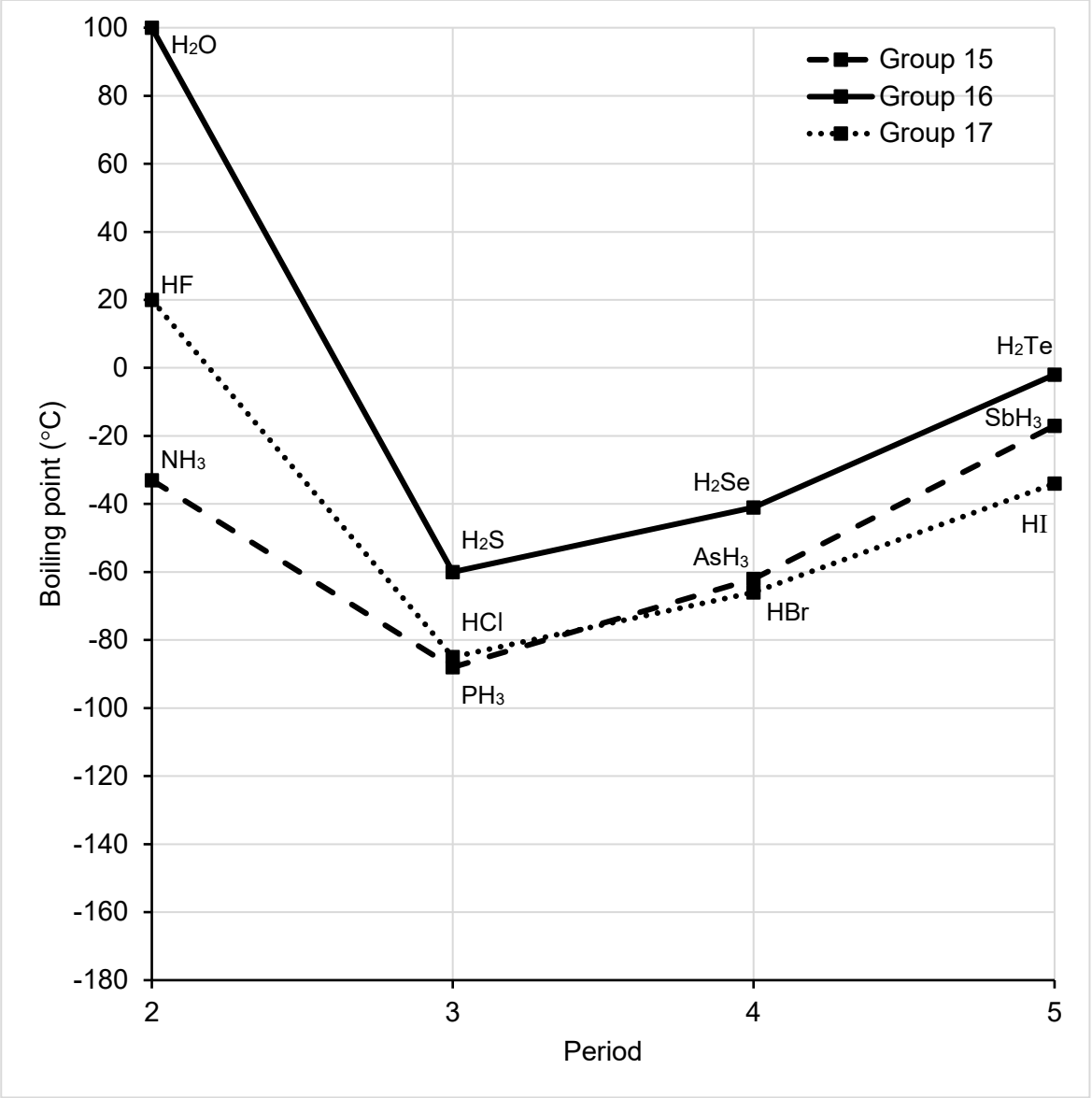
Question 37 (e)



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