



Carmel School

nistry: Semester 2 Examination, 2015

Question/Answer Booklet

Student Name:

TIME ALLOWED FOR THIS PAPER

Reading time before commencing work:	ten minutes
Working time for the paper:	2½ hours

MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

To be provided by the supervisor:

This Question/Answer Booklet
Multiple-choice Answer Sheet
Chemistry Data Book

To be provided by the candidate:

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, eraser, correction tape/fluid, ruler, highlighters

Special items: up to three non-programmable calculators approved for use in the WACE examinations

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	20	20	40	/40	/25
Section Two: Short answer	8	8	50	/56	/35
Section Three: Extended answer	5	5	60	/64	/40
					/100

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 questions 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.

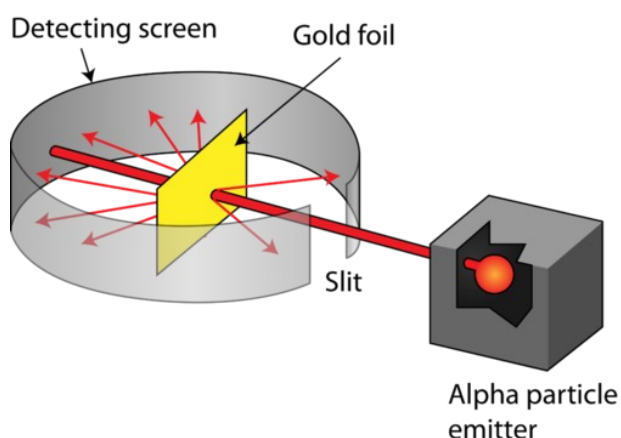
2. When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.
3. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.
4. Spare pages are included at the end of this booklet. 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** to be handed in with your Question/Answer Booklet.

Section One: Multiple-choice**25% (40 marks)**

This section has **20** 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: 40 minutes.

1. The diagram below illustrates Rutherford's experiment, where he fired α -particles at a very thin sheet of gold foil.



How did this experiment contribute to our understanding of the structure of the atom?

- (a) It lead to the discovery of the neutron
 (b) It lead to the plum pudding model of the atom
 (c) It lead to the hypothesis of an atom with a central nucleus
 (d) It lead to the discovery that electrons were negatively charged
2. The subatomic particle arrangement of five different species is shown below. Which of the following are **correct**?

	Species	Protons	Neutrons	Electron configuration
(i)	^{36}Cl	17	19	2,8,7
(ii)	$^{27}\text{Al}^{3+}$	13	14	2,8,3
(iii)	^{10}Be	4	6	2,2
(iv)	$^{16}\text{O}^{2-}$	8	8	2,8
(v)	^{14}N	7	7	2,7

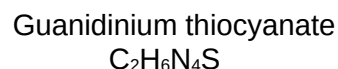
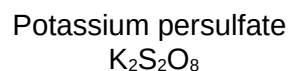
- (a) (i), (ii) and (v) only
 (b) (i), (iii) and (iv) only
 (c) (ii), (iii) and (iv) only
 (d) (ii), (iv) and (v) only

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3. Which of the following correctly identifies both a pure substance and a mixture?

	Pure substance	Mixture
(a)	salt water	air
(b)	ethanol	water
(c)	methane	stainless steel
(d)	sulfurous acid	ammonia

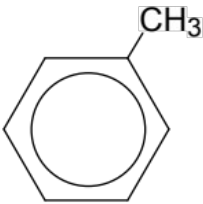
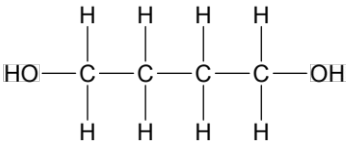
4. Consider the two sulfur-containing compounds below.



Which of these compounds contains the **highest** percentage of sulfur by mass and what is this value?

- (a) Potassium persulfate, 33.4%
 (b) Guanidinium thiocyanate, 27.1%
 (c) Potassium persulfate, 23.7%
 (d) Guanidinium thiocyanate, 28.6%

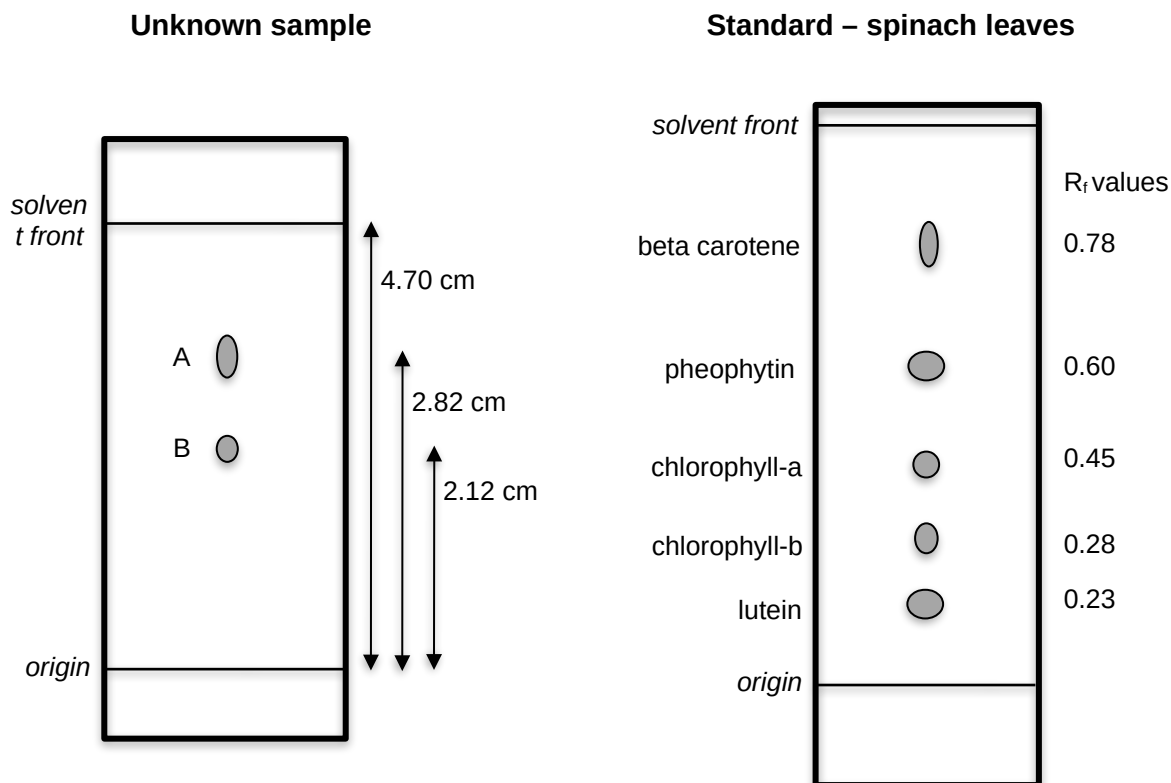
5. Consider the information given in the following table.

	Toluene	Butane-1,4-diol
Structural diagram		
Molar mass, M (g mol ⁻¹)	92.134	90.12
Vapour pressure at 50 °C (kPa)	12.28	0.014

Which is the **best** explanation for the difference in vapour pressure of these two compounds?

- (a) Toluene has a higher molar mass than butane-1,4-diol
 (b) Butane-1,4-diol has fewer carbon atoms in its structure than toluene
 (c) Toluene has stronger dispersion forces than butane-1,4-diol
 (d) Butane-1,4-diol has stronger intermolecular forces than toluene

6. A group of students were analysing the pigments in a plant leaf sample by thin layer chromatography (TLC). A diagram of their TLC plate is shown (below, left) as well as a standard TLC plate produced from the analysis of the pigments in spinach leaves (below, right).



The students calculated the retention factor, R_f , for the unidentified pigments A and B using the following formula;

$$R_f = \frac{\text{distance travelled by solute component}}{\text{distance travelled by solvent}}$$

Use the TLC data provided to determine the R_f value for pigment A and compare this to the standard TLC plate to identify A. You may assume the plates were run under identical conditions.

- (a) R_f value = 0.6 A is pheophytin
 (b) R_f value = 0.45 A is chlorophyll-a
 (c) R_f value = 0.78 A is beta carotene
 (d) R_f value = 1.7 A is beta carotene
7. Which of the following would have dispersion forces as the **only** intermolecular force present in a pure sample?
- (a) SO_2
 (b) CS_2
 (c) CH_2Cl_2
 (d) CO

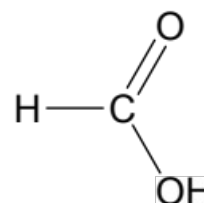
8. In which of the following are the covalent bonds ranked in order of decreasing polarity (i.e. most polar to least polar)?

- (a) $\text{H-O} > \text{H-F} > \text{H-Br} > \text{H-C}$
(b) $\text{H-C} > \text{H-Br} > \text{H-O} > \text{H-F}$
(c) $\text{H-F} > \text{H-C} > \text{H-O} > \text{H-Br}$
(d) $\text{H-F} > \text{H-O} > \text{H-Br} > \text{H-C}$

9. Which of these gives the correct shape for each of the covalent molecules?

- | | SO₃ | HCN | F₂O |
|-----|-----------------------|-----------------|-----------------------|
| (a) | pyramidal | linear | bent / v-shaped |
| (b) | trigonal planar | linear | bent / v-shaped |
| (c) | trigonal planar | bent / v-shaped | linear |
| (d) | pyramidal | trigonal planar | linear |

10. Formic acid (methanoic acid) is used as a preservative and antibacterial agent, as well as in various cleaning products. It has boiling point of 101 °C and its structure is shown to the right.



a

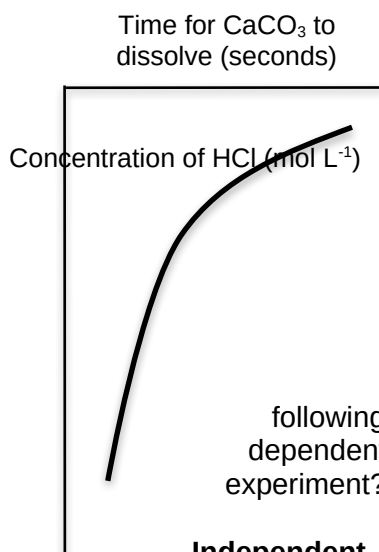
Which of the following substances would be **least** soluble in formic acid?

- (a)
- (b)
- (c)
- (d)

Questions 11 and 12 relate to the following experiment.

A group of chemistry students set up an experiment to investigate reaction rate. They had 5 beakers, each containing the same mass of calcium carbonate powder. To each beaker they added 50.0 mL of hydrochloric acid. The concentration of the hydrochloric acid in each beaker was 0.25 mol L⁻¹, 0.5 mol L⁻¹, 0.75 mol L⁻¹, 1.0 mol L⁻¹ and 1.25 mol L⁻¹ respectively. In each case they measured how long it took, in seconds, for the calcium carbonate powder to dissolve completely.

The equation for the reaction that took place in each beaker is shown below, along with a graph summarising their data.



11. Which of the variable, this

following correctly states the independent dependent variable and a controlled variable in experiment?

Controlled

- (a) time for CaCO₃ to dissolve
(b) concentration of HCl
(c) time for CaCO₃ to dissolve
(d) concentration of HCl

Independent

- concentration of HCl
time for CaCO₃ to dissolve
volume of HCl
mass of CaCO₃

Dependent

- mass of CaCO₃
volume of HCl
temperature of room
volume of HCl

12. Looking at the students' graph, what trend can be identified from the data collected in this experiment?
- (a) With an increase in HCl concentration, the CaCO₃ takes longer to dissolve
(b) With an increase in HCl concentration, there are more collisions occurring between the reactant particles
(c) With an increase in HCl concentration, less CaCO₃ is consumed
(d) With an increase in HCl concentration, there is an increased rate of reaction

13. What physical property of water does the paragraph below describe?

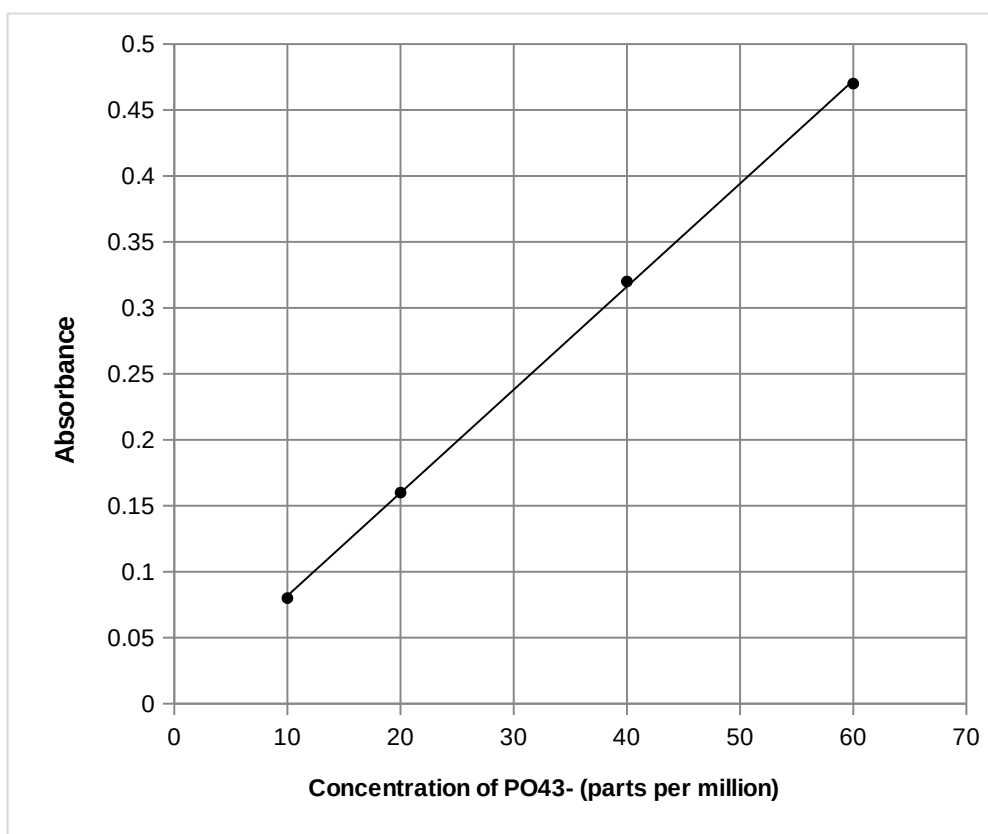
"Water molecules are strongly attracted to each other through cohesive forces. In liquid water, most molecules are attracted to neighbouring water molecules above, below and on all sides. However, the molecules at the surface of the liquid do not have water molecules above them and are therefore pulled more strongly downwards by the water molecules below them."

- (a) Surface tension
(b) Hydrogen bonding

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- (c) Vapour pressure
(d) Density
14. If the volume of a constant mass of gas is halved at constant temperature, which of the following are **true**?
- (i) the pressure of the gas would increase
(ii) the average kinetic energy of the gas would increase
(iii) the number of collisions between the gas particles would increase
- (a) (i) only
(b) (i) and (iii) only
(c) (iii) only
(d) (i) and (ii) and (iii)
15. A phosphate blood test is often done when a patient is suspected of having kidney or gastrointestinal disorders. The concentration of phosphate (PO_4^{3-}) in the blood is measured using high performance liquid chromatography (HPLC). HPLC is used to obtain an absorbance reading for the patient's blood phosphate level, and this then is compared to a set of standards to determine the blood concentration of phosphate.

The standard concentration curve for phosphate is shown in the graph below.



Use the information provided to determine the level of phosphate in a patient's blood if the phosphate absorbance reading obtained from HPLC analysis of their blood was 0.42.

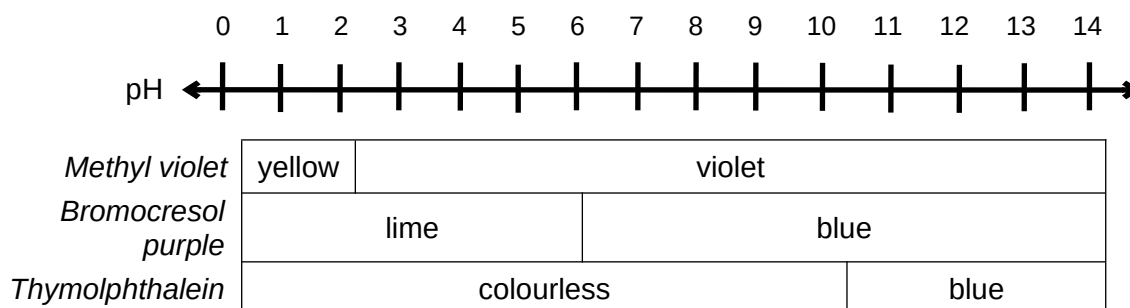
- (a) 0.25 ppm
(b) 0.34 ppm
(c) 48 ppm
(d) 53 ppm

16. Which of the following statements are **true** regarding enzymes?

- (i) Enzymes are catalysts
 - (ii) Enzymes lower the ΔH of a reaction
 - (iii) Enzymes increase the rate of reaction
 - (iv) Enzymes increase the proportion of successful collisions
 - (v) Enzymes increase the kinetic energy of particles
- (a) (i), (iii) and (iv) only
 - (b) (i), (ii) and (iii) only
 - (c) (i), (iv) and (v) only
 - (d) (iii), (iv) and (v) only

Questions 17 relates to the following information.

The following diagram shows the colour of three indicators for varying pH values.



17. What colour would you expect a 1.0 mol L^{-1} solution of potassium hydroxide (KOH) to turn if a few drops of each of these indicators was added to different samples of potassium hydroxide solution?

- | | Methyl violet | Bromocresol purple | Thymolphthalein |
|-----|----------------------|---------------------------|------------------------|
| (a) | violet | blue | blue |
| (b) | blue | violet | colourless |
| (c) | yellow | blue | colourless |
| (d) | blue | violet | blue |

18. A 99.0 g sample of cobalt(II) chloride was added to 150 mL of water at 20°C and the solution was stirred until no more solute would dissolve. Some of the CoCl_2 remained undissolved at the bottom of the beaker. The solution was then heated from 20°C to 40°C while stirring. If the solubility of cobalt(II) chloride at 40°C is 69.5 g per 100 mL of water, what observation would have been noted as the solution reached its final temperature?

- (a) No change would be observed
- (b) More solute crystals would appear
- (c) Some solute crystals would dissolve
- (d) All solute crystals would dissolve

Question 19 relates to the following energy profile diagram.



19. What are the values for the heat of enthalpy (ΔH) and the activation energy (E_a) for this reaction?

	ΔH (kJ)	E_a (kJ)
(a)	-200	+300
(b)	+200	+500
(c)	-200	+500
(d)	+200	+100

20. A small sample of sodium carbonate solution is mixed with hydrochloric acid. Which of the following correctly shows the balanced ionic equation for the reaction that would take place?

- (a) $\text{Na}_2\text{CO}_3(\text{aq}) + 2 \text{H}^+(\text{aq}) \rightarrow 2 \text{Na}^+(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$
(b) $\text{CO}_3^{2-}(\text{aq}) + 2 \text{H}^+(\text{aq}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$
(c) $\text{Na}_2\text{CO}_3 + 2 \text{HCl}(\text{aq}) \rightarrow 2 \text{NaCl}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$
(d) $\text{CO}_3^{2-}(\text{aq}) + 2 \text{H}^+(\text{aq}) \rightarrow \text{H}_2\text{CO}_3(\text{aq})$

End of Section One

Section Two: Short answer

35% (56 marks)

This section has **8** questions. Answer **all** questions. Write your answers in the spaces provided.

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.

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Suggested working time: 50 minutes.

Question 26

(6 marks)

Cobalt is a silver metal which is malleable and ductile. Chlorine is a pale yellow-green gas at room temperature. However, when these two elements combine, they produce brittle crystals of blue cobalt(II) chloride. Explain these differences in physical properties, in terms of the structure and bonding of the three substances.

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Question 27**(7 marks)**

Dry ice is the name given to solid carbon dioxide (CO_2). It is often used in theatre productions, because at room temperature dry ice will 'sublime' or turn from the solid state directly into a gas. This creates white 'clouds' that can be used for various special effects.

- (a) A small piece of dry ice was placed in a sealed metal container at room temperature. Explain, in terms of the kinetic theory, why the pressure inside the container would have changed once the piece of dry ice has sublimed and the container had returned to room temperature. (2 marks)

Under conditions of high pressure and/or low temperature, gases will not behave as 'ideal gases'.

- (b) State one example of how gases vary from the expected behaviour of ideal gases. Explain why this variation occurs. (2 marks)

- (c) A 3.75 L cylinder was storing 5.28 g of a gas at STP. Could the identity of this gas be carbon dioxide? Explain, showing all working. (3 marks)

Question 28**(10 marks)**

Consider the solubility information given in the table below.

	Solubility in water (g per 100 mL)
Potassium nitrate (KNO_3)	32
Ammonium nitrate (NH_4NO_3)	150
Potassium phosphate (K_3PO_4)	90

- (a) Classify the solutions below as 'saturated', 'unsaturated' or 'supersaturated'. Explain your reasoning. (5 marks)

- (i) 216 g of K_3PO_4 was dissolved in 240 mL of water.

- (ii) 0.375 mol of KNO_3 was dissolved in 170 mL of water.

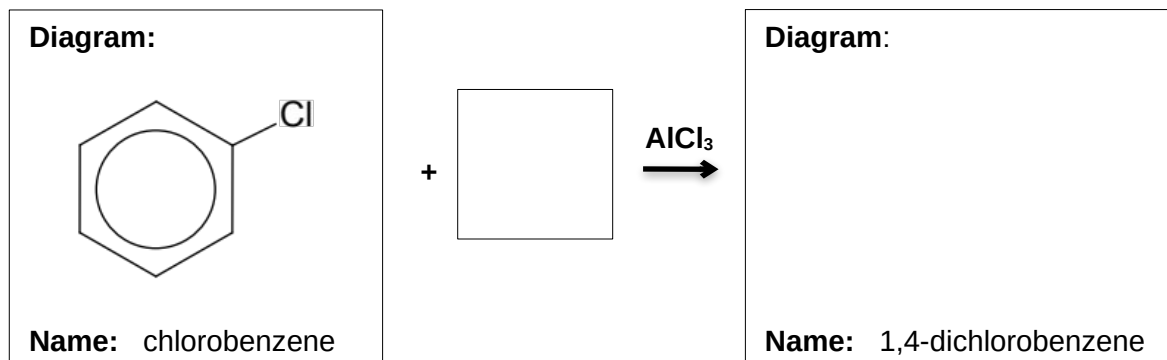
The two solutions described in part (a) were mixed together.

- (b) Calculate the final concentration (in mol L^{-1}) of potassium ions (K^+) in the resulting solution. (5 marks)

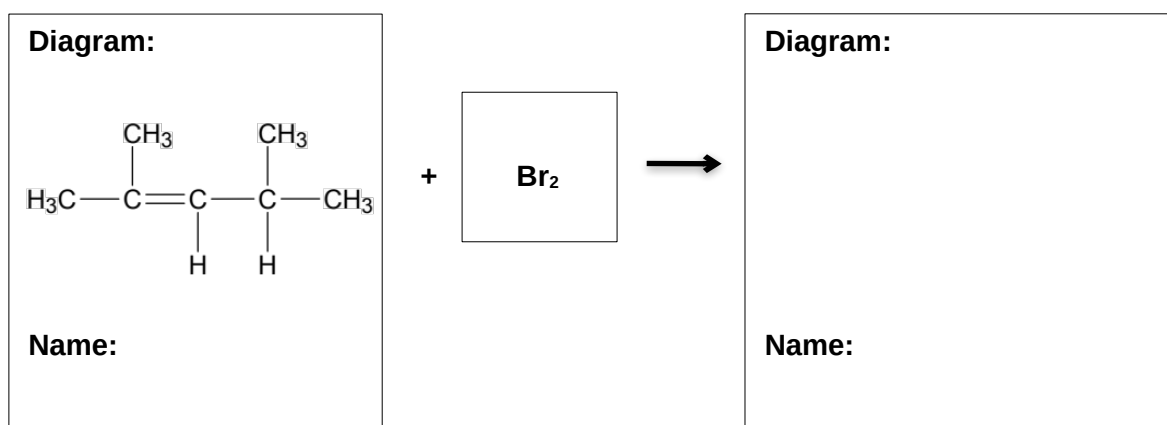
Question 29**(7 marks)**

Organic compounds can undergo many different types of reactions.

- (a) Complete the reaction below by adding the inorganic reactant and drawing the structural diagram for the organic product formed. (2 marks)



- (b) Complete the reaction below by giving the IUPAC name for the organic reactant and the structural diagram and IUPAC name for the organic product formed. (3 marks)



- (c) Name the type of reaction occurring in; (2 marks)

- (a) _____
- (b) _____

Question 31

(6 marks)

Most modern cars are powered by an engine with a 4-stroke combustion cycle. The purpose of each stroke is described below.

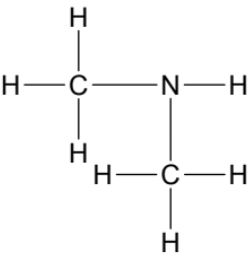
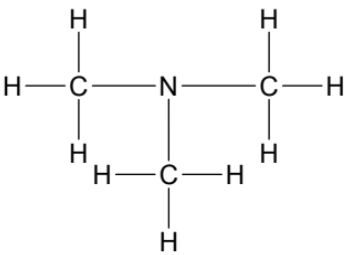
1. Intake stroke - the fuel is injected in as a fine mist, where it mixes with air
2. Compression stroke - the fuel/air mixture is compressed into a small volume
3. Combustion stroke - a spark plug ignites the fuel/air mixture, which explodes
4. Exhaust stroke - exhaust fumes leave through the valve

Explain, in terms of the collision theory, how each of the conditions described in **stroke 1, 2 and 3** affect the rate of reaction between the fuel and the air.

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Question 32**(7 marks)**

Consider the information given in the table below.

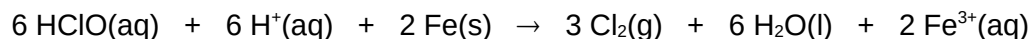
Dimethylamine	Trimethylamine
	
Boiling point 8 °C	Boiling point -3 °C

- (a) Dimethylamine has the ability to form hydrogen bonds. Explain in detail how hydrogen bonds form and draw a diagram showing these bonds in dimethylamine. (4 marks)

- (b) Explain why trimethylamine has the stronger dispersion forces, but dimethylamine has the higher boiling point. (3 marks)

Question 33**(5 marks)**

The equation below represents the reaction between solid iron (Fe) and hypochlorous acid (HClO).



A piece of iron was placed in a solution of 1.53 mol L^{-1} hypochlorous acid. The reaction was allowed to go to completion and at the end all of the solid iron had reacted. If 1.48 L of Cl_2 was produced at STP;

- (a) Calculate the volume of HClO that would have been required for the reaction to take place. (3 marks)

- (b) Calculate the mass of iron that must have been present. (2 marks)

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End of Section Two

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Section Three: Extended answer**40% (64 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.

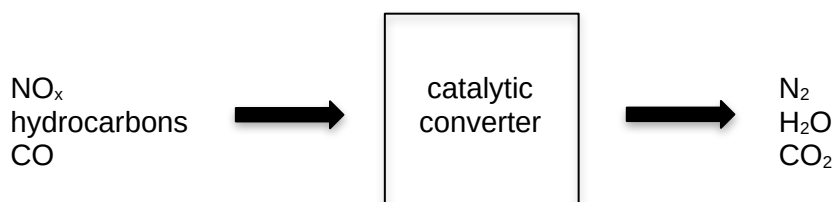
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Suggested working time: 60 minutes.

Question 34**(16 marks)**

The catalytic converter in a car takes in the undesirable gases produced by the combustion of petrol, such as carbon monoxide and various nitrogen oxides, and converts them into less harmful gases such as carbon dioxide, nitrogen gas and water. The less harmful gases are released into the atmosphere as we drive.



Metals such as platinum, palladium and rhodium are used as the catalyst in a catalytic converter.

- (a) Explain what a catalyst is and describe its effect on the rate of a reaction. (3 marks)

The table below shows the major gaseous products to exit a catalytic converter.

- (b) Complete this table by drawing the structural formula for each of the three gases, representing all valence shell electron pairs either as : or –. In addition, state the shape of the molecule, and indicate whether or not the molecule contains polar bonds or is a polar molecule. (6 marks)

	Structural diagram	Shape	Polar bonds (‘yes’ or ‘no’)	Polar molecule (‘yes’ or ‘no’)
N ₂				
CO ₂				
H ₂ O				

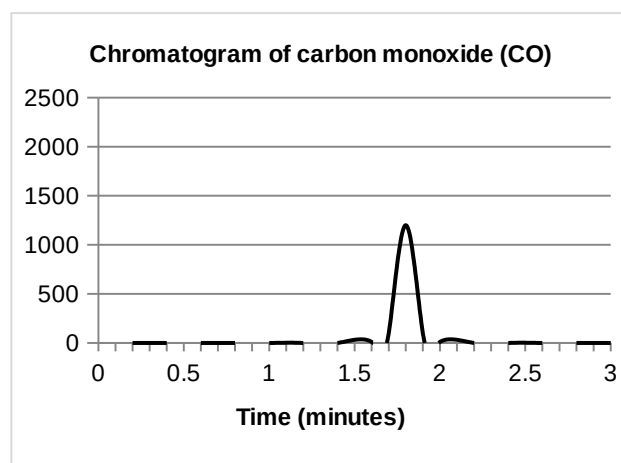
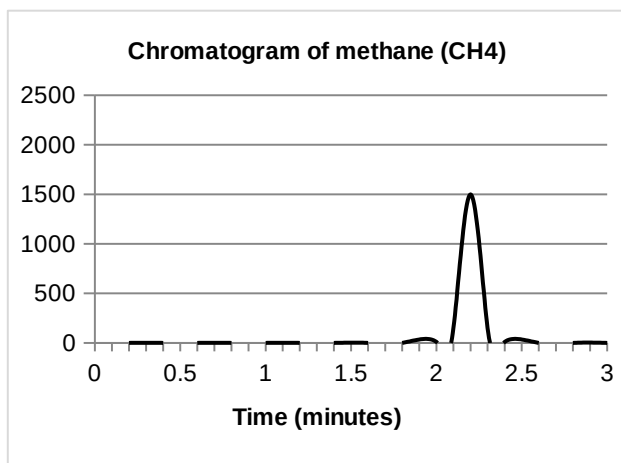
A sample of exhaust fumes from a car was analysed by gas chromatography (GC) to determine the composition of the fumes and assess the effectiveness of the catalytic converter.

- (c) Briefly describe the principles of gas chromatography and state one reason why GC may have been chosen over other forms of chromatography to perform the analysis in this situation. (4 marks)

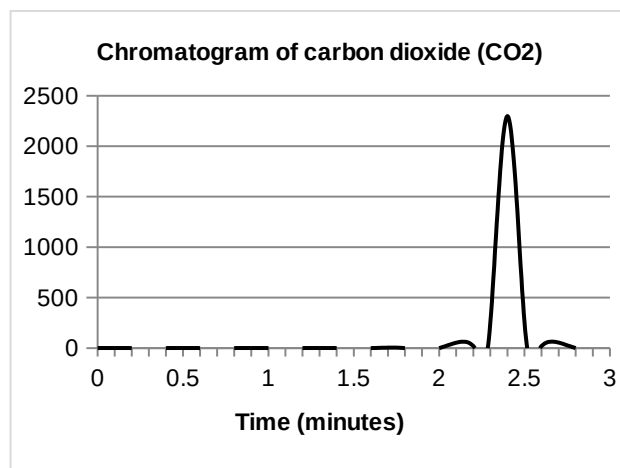
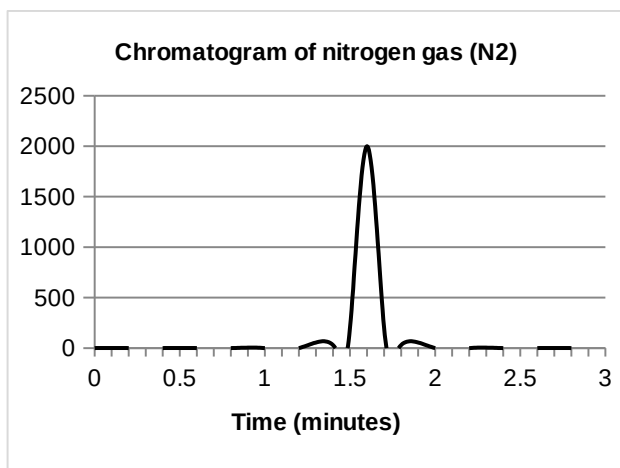
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The data below shows GC standards for four of the relevant gases, as well as the chromatogram obtained from analysis of the car exhaust fumes.

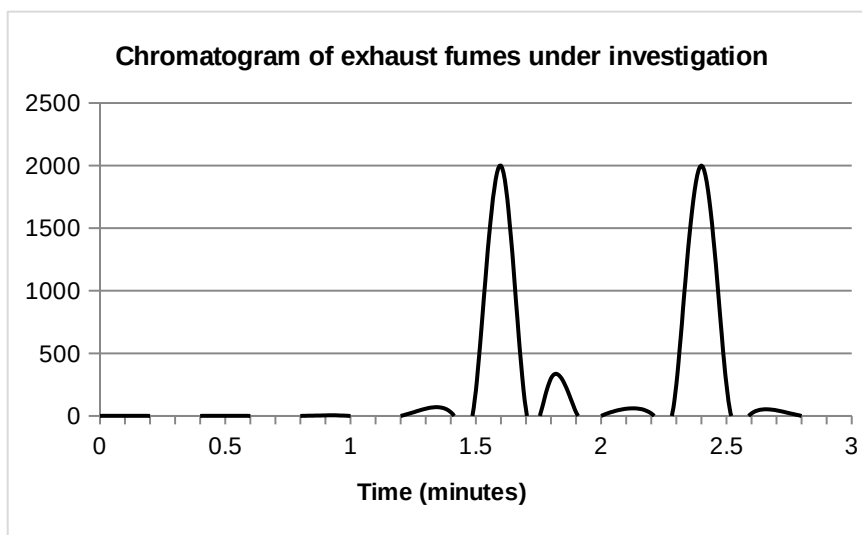
The two chromatograms below, for methane and carbon monoxide, were obtained from the analysis of car exhaust fumes that **do not pass** through a catalytic converter.



The two chromatograms below, for nitrogen and carbon dioxide, were obtained from the analysis of exhaust fumes released from an **efficiently functioning** catalytic converter.



The chromatogram for the sample of exhaust fumes being analysed is shown below.



SEE NEXT PAGE

- (d) Elaborate on the information provided by this data, in terms of the composition of the car exhaust fumes and the effectiveness of the catalytic converter. (3 marks)

Question 35**(12 marks)**

Carbon is the basis of all life on Earth. It is the element upon which DNA, proteins and all other organic compounds are based. The field of 'organic chemistry' is dedicated entirely to those substances containing a carbon backbone. In addition to this, carbon is found in many inorganic compounds such as carbon dioxide, limestone and baking soda. Pure carbon exists in several different forms such as diamond, graphite, buckyballs and carbon nanotubes.

- (a) The two most common allotropes of carbon are diamond and graphite. What is an allotrope? (1 mark)

Diamond possesses all the typical properties of a covalent network substance.

- (b) Briefly outline and explain these properties in terms of the structure and bonding present in diamond. (4 marks)

Graphite has some properties that are **not** typical of covalent network substances.

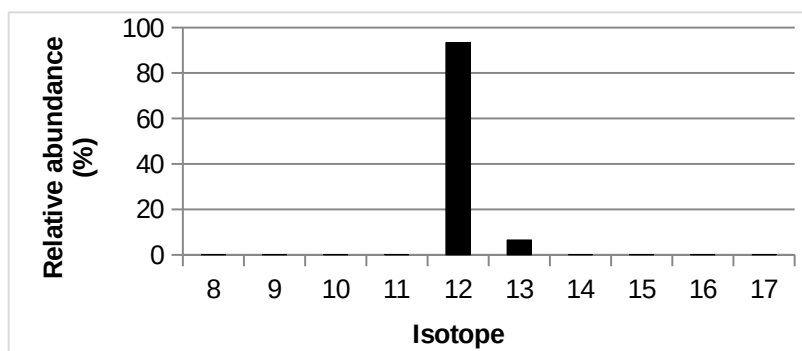
- (c) Briefly outline and explain these differences in terms of the structure and bonding present in graphite. (3 marks)

A third allotrope of carbon are the fullerenes. These structures come in many different shapes, forms and sizes. One type of fullerene is the carbon nanotube (CNT). Carbon nanotubes have a similar structure to graphite and are an example of a 'nanomaterial'. Due to the small particle size, it is often stated that nanomaterials have properties that differ from the bulk material.

- (d) What are 'nanomaterials'? Give one example of how the properties of a nanomaterial are different from the bulk material from which they are formed. (2 marks)

A sample of extra-terrestrial carbon nanotube was found on a meteorite that had fallen in the desert in central Australia. The sample was analysed by mass spectrometry to determine its isotopic composition and therefore calculate the atomic mass of the carbon comprising it.

The following data was obtained from the mass spectrometer.



Isotope	Atomic mass	Percent abundance
^{12}C	12.000 u	93.41%
^{13}C	13.003 u	6.59%

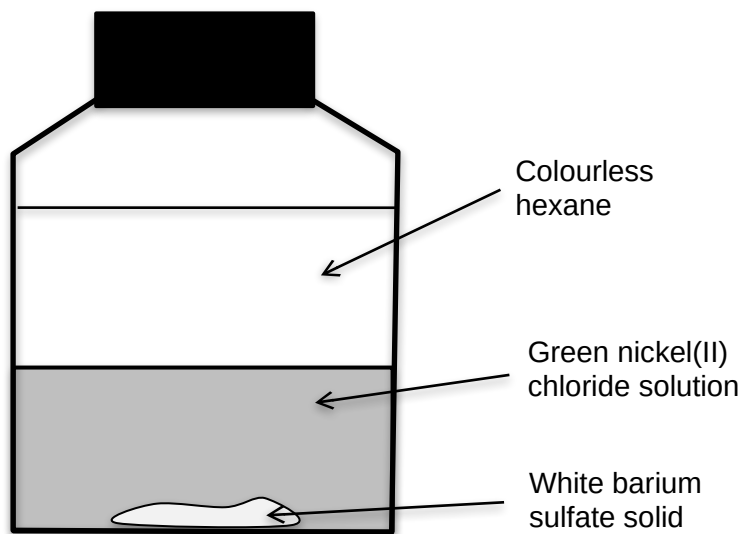
- (e) Use the data above to calculate the atomic mass of the extra-terrestrial carbon sample. (2 marks)

Question 36**(11 marks)**

A group of chemistry students were given the task of separating a mixture into its individual components. They were given a jar with four different compounds mixed together. The four components of the mixture were as follows;

- 50 mL of hexane
- 50 mL of water
- 0.5 g of nickel(II) chloride, and
- 0.5 g of barium sulfate.

A sketch of the appearance of the mixture is shown in the diagram below.



The students were also given several pieces of data regarding each compound in the mixture. This is given in the table below.

	Appearance at room temperature	Boiling point (°C)	Density (g mL⁻¹)
Hexane	Colourless liquid	68	0.655
Water	Colourless liquid	100	1
Nickel(II) chloride	Green solid	973	-
Barium sulfate	White solid	1600	-

- (a) Explain why nickel(II) chloride is soluble in water, but hexane is not. (4 marks)

- (b) Calculate the concentration of chloride ions (Cl^-) in the aqueous layer of the mixture. (3 marks)

- (c) Explain how you could separate the mixture to produce pure samples of each of the four original compounds. (4 marks)

Question 37

(9 marks)

A chemist was preparing for his next experiment by organising and labelling all his bottles of solutions. He had five bottles to go when the fire alarm went off for a practice safety drill. When he got back to his bench later he found five bottles, each containing a clear colourless liquid. Next to these bottles were the remaining five labels;

Barium hydroxide $\text{Ba}(\text{OH})_2$ 0.25 mol L ⁻¹	Sodium chloride NaCl 0.25 mol L ⁻¹	Ethanoic acid CH_3COOH 0.25 mol L ⁻¹
Hydrochloric acid HCl 0.25 mol L ⁻¹	Sodium hydroxide NaOH 0.25 mol L ⁻¹	

He set about identifying each solution so that he could finish labelling them. He began by adding a few drops of sulfuric acid to a small sample of each. This test allowed him to identify the $\text{Ba}(\text{OH})_2$ solution straight away.

- (a) What observation would he have made to allow this identification? Write the ionic equation for the reaction that could have taken place in the test tube containing $\text{Ba}(\text{OH})_2$. (2 marks)

Universal indicator was then added to new samples of the remaining four unidentified solutions.

- (b) Explain how an indicator works and describe how this test would allow **clear** identification of **two** of the substances. (3 marks)

A piece of zinc metal was added to the final two solutions. In one solution, a fast reaction was seen, with much effervescence (bubbles). The other test tube also showed some effervescence but at a much slower rate.

- (c) Explain in detail why a difference in reaction rate was observed between these two solutions and how this observation allowed the chemist to identify and distinguish these two solutions from one another. (4 marks)

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Question 38**(16 marks)**

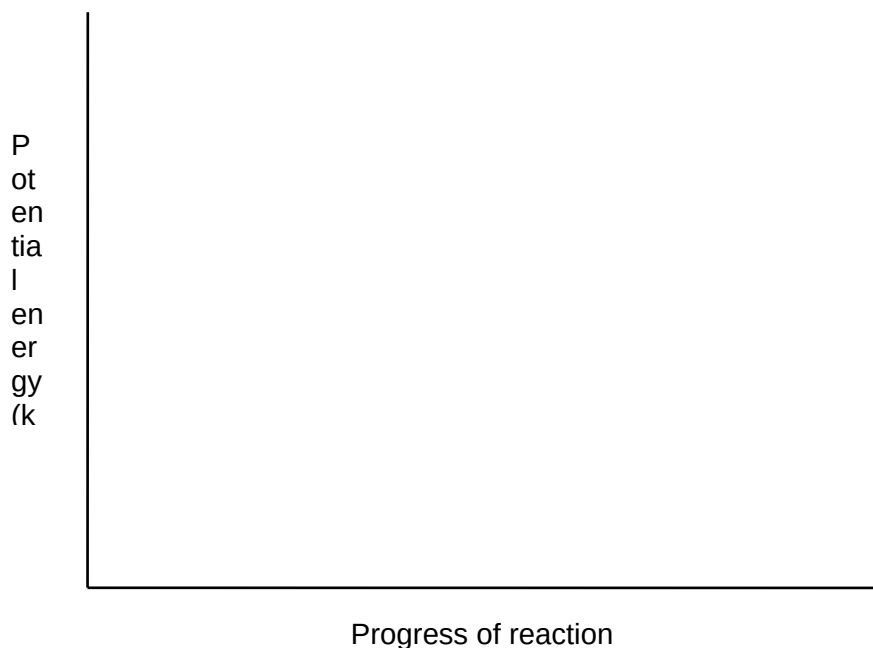
Bioethanol is the same compound as ethanol (C₂H₅OH) but refers to ethanol that has been produced from 'biomass', which is a renewable resource. Ethanol is a useful fuel and combusts according to the following equation;



- (a) Explain briefly how bioethanol is produced. (1 mark)

If the activation energy for the combustion reaction above is 387 kJ;

- (b) Draw a fully labelled energy profile diagram, to scale, for the combustion of ethanol. (4 marks)



- (c) Explain how the Law of Conservation of Energy applies to your energy profile diagram. (2 marks)

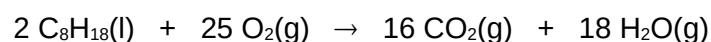
Octane (C_8H_{18}) is a hydrocarbon fuel, which is obtained from the fractional distillation of crude oil. Unlike bioethanol it is a non-renewable resource. Octane and its many structural isomers can be found as components of the petrol we use to power our cars.

- (d) Briefly describe the composition of petrol. (2 marks)

The activation energy for the combustion of octane is substantially higher than the activation energy for the combustion of ethanol.

- (e) What information does this give you about ethanol and octane? (2 marks)

The equation representing the combustion of octane is shown below. The enthalpy change for the combustion is $-5470 \text{ kJ mol}^{-1}$ of octane.



- (f) If 1.55 kg of octane was burnt, calculate the amount of heat energy released **and** the volume of carbon dioxide produced at STP. (5 marks)

End of questions

Spare answer page

Question number: _____