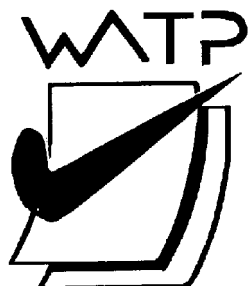


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CHEMISTRY

UNITS 1 & 2

2016

Name: _____

Teacher: _____

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:

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	25	25	50	/50	/25
Section Two: Short answer	8	8	60	/70	/35
Section Three: Extended answer	5	5	70	/80	/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** handed in with your Question/Answer Booklet.

Section One: Multiple-choice

25% (50 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 information shown in the table below.

Symbol	Number of protons	Electron configuration
Si	14	X
Y	12	2, 8
N ³⁻	7	Z

Which of the following are correct for X, Y and Z?

	X	Y	Z
(a)	2, 8, 4	Ar	2, 8
(b)	2, 8, 4	C	2, 5
(c)	2, 8, 4	Mg ²⁺	2, 8
(d)	2, 8, 2	Mg	2, 5

2. Which of the following properties of water cannot be explained by the formation of hydrogen bonds?

- (a) The relatively low vapour pressure of water.
- (b) The molecular shape of water.
- (c) The relatively high melting point of water.
- (d) The lower density of solid water compared to liquid water.

3. Read the statements below which refer to the structure and bonding of substances W, X, Y and Z.

W is unable to dissolve in water and will only shatter when a very large force is applied.

X is able to conduct electricity in both the solid and liquid states.

Y is composed of a brittle lattice.

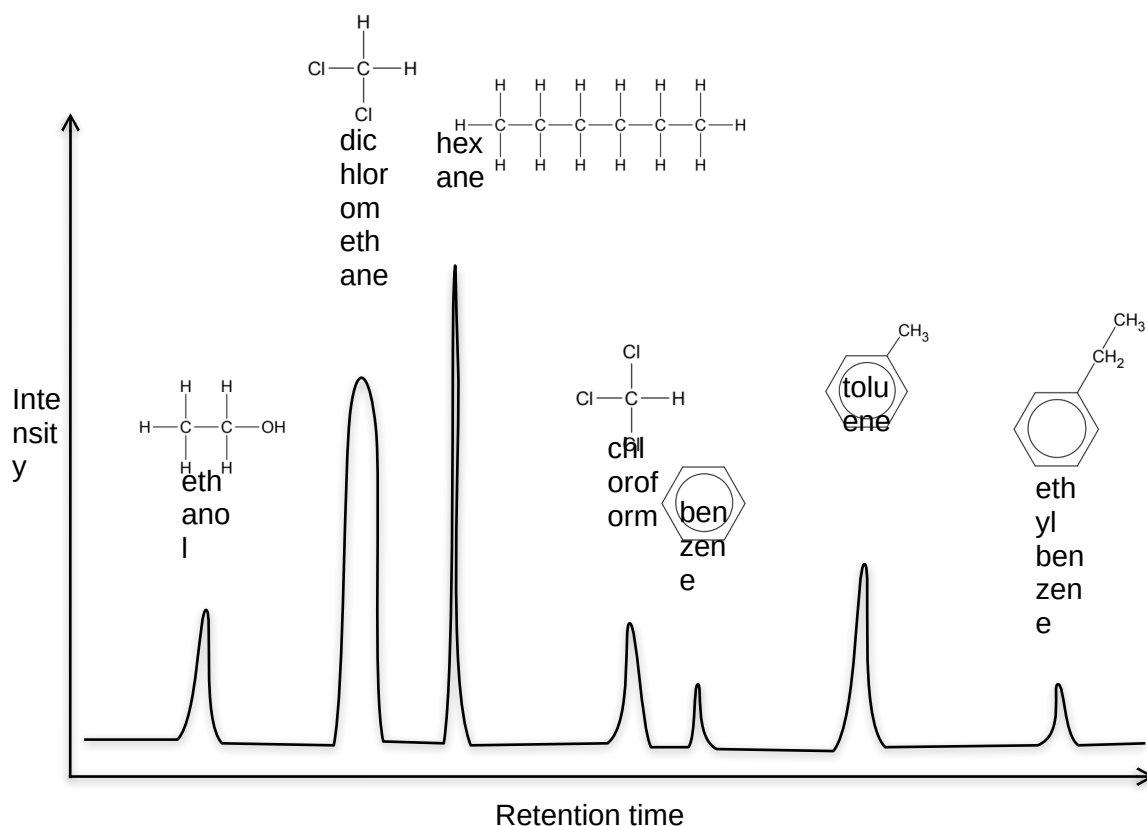
Z is a gas at room temperature.

Use the information given above to determine which of the following statements is **most likely** to be **correct**?

- (a) Y has weak intermolecular forces between its molecules.
- (b) Z has a very high thermal conductivity.
- (c) X is malleable and ductile.
- (d) W will conduct electricity when molten.

Questions 4 and 5 refer to the information below.

The following gas chromatogram shows an analysis of the volatile organic compounds (VOCs) in an air sample collected above the city of Tokyo.



4. Which of the following statements regarding the chromatogram is **correct**?
 - (a) Ethyl benzene elutes last because it is the most polar VOC.
 - (b) Dichloromethane elutes before hexane because it is a more polar VOC.
 - (c) The VOCs elute in order of lowest to highest molecular weight.
 - (d) Ethanol elutes first because it is the most volatile VOC.

5. Use the chromatogram to estimate which VOC is present in the air sample in greatest concentration.
 - (a) Ethanol.
 - (b) Dichloromethane.
 - (c) Hexane.
 - (d) Toluene.

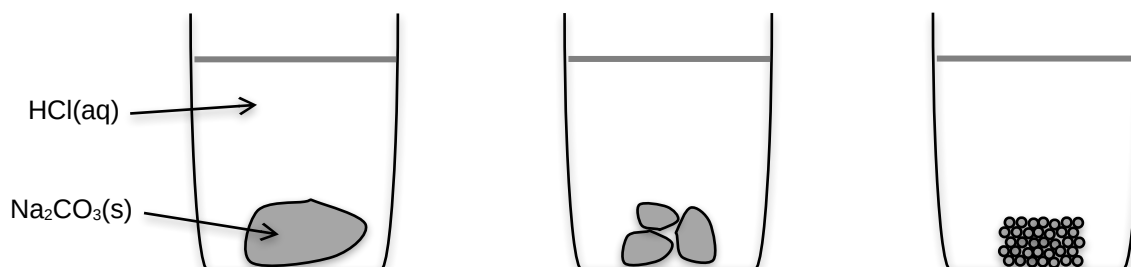
6. A student weighed out 7.30 g of sugar ($C_{12}H_{22}O_{11}$). Calculate the number of carbon atoms that would have been present in this sample.
 - (a) 0.021 atoms
 - (b) 1.28×10^{22} atoms
 - (c) 1.93×10^{22} atoms
 - (d) 1.54×10^{23} atoms

SEE NEXT PAGE

Questions 7 and 8 refer to the information below.

A group of chemistry students was investigating factors that may affect reaction rate.

They placed an equal volume and concentration of hydrochloric acid, HCl(aq) , into three (3) beakers. They then weighed out three (3) equal masses of sodium carbonate, $\text{Na}_2\text{CO}_3\text{(s)}$. The first Na_2CO_3 sample was a solid lump, the second was in small pieces and the third was a powdered sample.



Each sample of solid Na_2CO_3 was added to a different beaker of HCl and the time taken for the solid to dissolve was measured and recorded.

7. State the independent and dependent variables in this investigation.

	Independent	Dependent
(a)	Mass of Na_2CO_3	Volume of HCl
(b)	Subdivision of Na_2CO_3	Time for Na_2CO_3 to dissolve
(c)	Volume of HCl	Subdivision of Na_2CO_3
(d)	Time for Na_2CO_3 to dissolve	Mass of Na_2CO_3

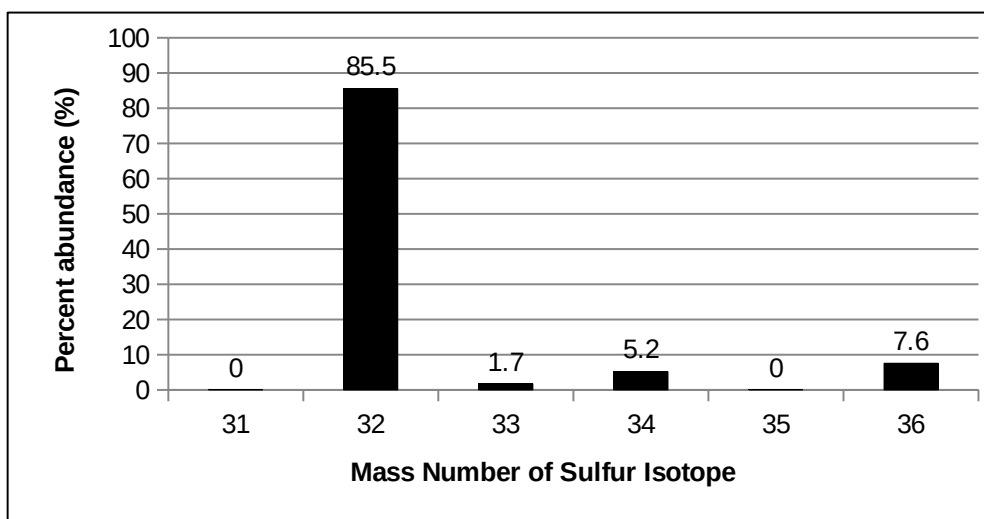
8. Using knowledge of the collision theory, predict and explain the expected results of this experiment.

- (a) The rate of reaction was the same in each beaker because the same mass of solid, and therefore the same number of collisions, is occurring.
- (b) The rate of reaction increased as the subdivision of Na_2CO_3 increased because a larger proportion of particles were able to overcome the activation energy barrier.
- (c) The rate of reaction would have been the same in each beaker provided the students made sure that all the controlled variables were kept constant.
- (d) The rate of reaction increased as the subdivision of Na_2CO_3 increased due to a larger surface area of reactants available for collision.

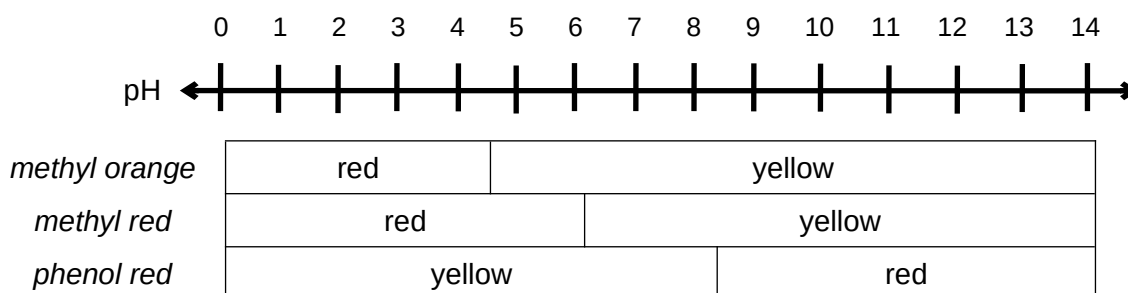
9. Which of the following statements is **not** correct regarding an ideal gas?

- (a) The volume of 1 mole of an ideal gas at STP is 22.71 litres.
- (b) The volume of 1 mole of an ideal gas at absolute zero is 0 litres.
- (c) The particles of an ideal gas are weakly attracted to one another.
- (d) The average kinetic energy of ideal gas particles is proportional to temperature.

10. Use the following mass spectrometry data to calculate the relative atomic mass of this sample of sulfur collected from the atmosphere of the planet Venus.



- (a) 32.07
 (b) 32.43
 (c) 32.18
 (d) 32.53
11. Information regarding the colour changes of three (3) acid-base indicators is shown in the diagram below.



Two unknown solutions, A and B, were tested with a few drops of each indicator and the results are shown in the table below.

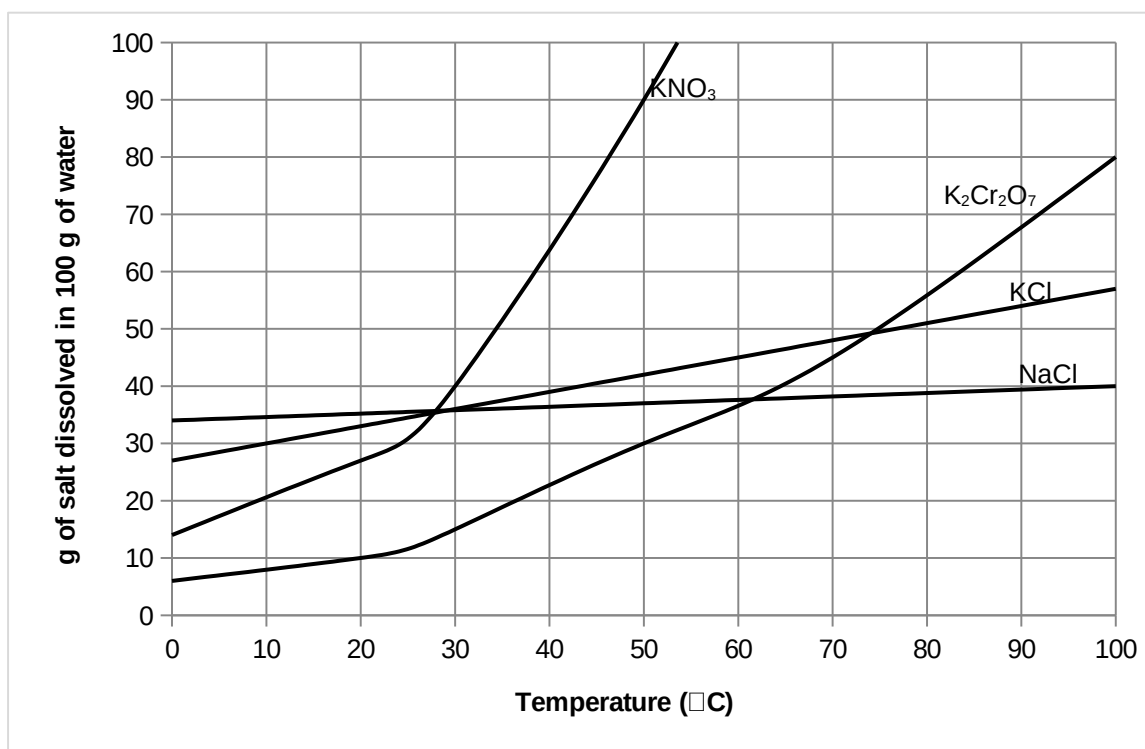
Indicator	Unknown A	Unknown B
<i>methyl orange</i>	yellow	yellow
<i>methyl red</i>	red	yellow
<i>phenol red</i>	yellow	yellow

Based on the data collected, which of the following statements is **correct**?

- (a) The pH of A is less than B.
 (b) The pH of B is greater than 7.
 (c) The pH of A may be neutral.
 (d) The concentration of hydrogen ions in B is greater than A.

Questions 12, 13 and 14 relate to the information below.

Examine the graph below, which shows how the aqueous solubility of four (4) different salts (KNO_3 , $\text{K}_2\text{Cr}_2\text{O}_7$, KCl and NaCl) vary with water temperature.



12. What trend can be summarised from this data, with regard to the solubility of salts?
- (a) The solubility of a salt increases with increasing molecular weight.
 - (b) The solubility of a salt increases linearly with increasing temperature.
 - (c) Salts with identical cations have very similar patterns of solubility.
 - (d) The solubility of a salt increases with increasing temperature.
13. Which of the following would constitute a supersaturated solution?
- (a) Dissolving 30 g of NaCl in 100 g of water at 70 °C.
 - (b) Dissolving 50 g of KNO_3 in 100 g of water at 40 °C.
 - (c) Dissolving 60 g of $\text{K}_2\text{Cr}_2\text{O}_7$ in 100 g of water at 80 °C.
 - (d) Dissolving 40 g of KCl in 100 g of water at 50 °C.
14. Which of the four salt solutions would be most easily distinguished from the others using a flame test?
- (a) KNO_3
 - (b) $\text{K}_2\text{Cr}_2\text{O}_7$
 - (c) KCl
 - (d) NaCl

15. For which of the following does the name **correctly match** the formula given?

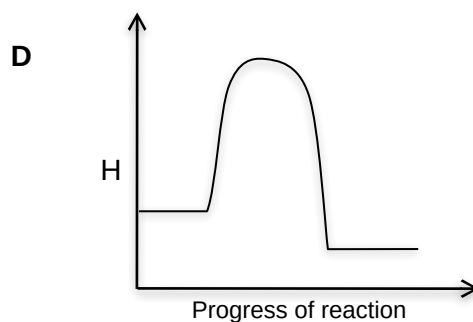
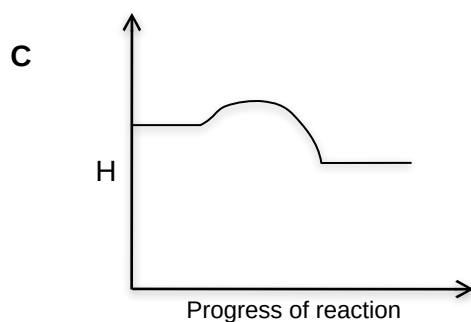
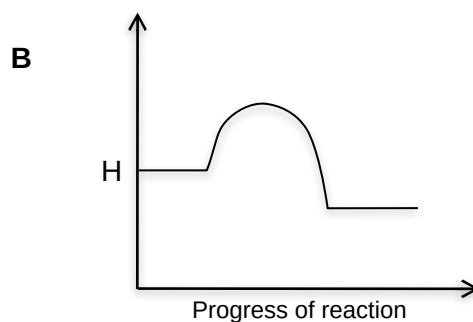
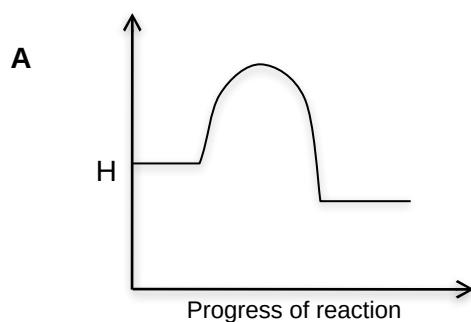
- (i) Carbon oxide, CO
- (ii) Lithium sulfate, LiSO_4
- (iii) Aluminium carbonate, $\text{Al}_2(\text{CO}_3)_3$
- (iv) Zinc hydroxide, $\text{Zn}(\text{OH})_2$
- (v) Sulfurous acid, H_2SO_2

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

16. Which of the following statements is **not** correct regarding the function of catalytic converters?

- (a) They reduce the emission of harmful gases into the atmosphere.
- (b) They ensure no carbon dioxide is released into the atmosphere.
- (c) They use metal catalysts to increase the rate of reaction.
- (d) They help reduce the levels of pollution and acid rain.

17. Consider the four energy profile diagrams shown below, where each has a very similar ΔH value. (You may assume the scale on each axis is identical.)

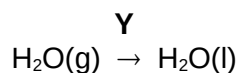
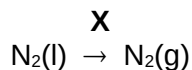


Based only on the information in these energy profile diagrams, which reaction is **most likely** to have the fastest rate?

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

18. When liquid nitrogen is poured into a container at room temperature, it quickly turns into a gas because its boiling point is -196°C . The white clouds that form around the liquid/gaseous nitrogen are actually made from water droplets in the air that have condensed due to the extremely cold temperature.

The relevant chemical equations for this described phenomenon are;



State whether X and Y are endothermic or exothermic processes.

- | | X | Y |
|-----|-------------|-------------|
| (a) | Endothermic | Exothermic |
| (b) | Exothermic | Endothermic |
| (c) | Endothermic | Endothermic |
| (d) | Exothermic | Exothermic |

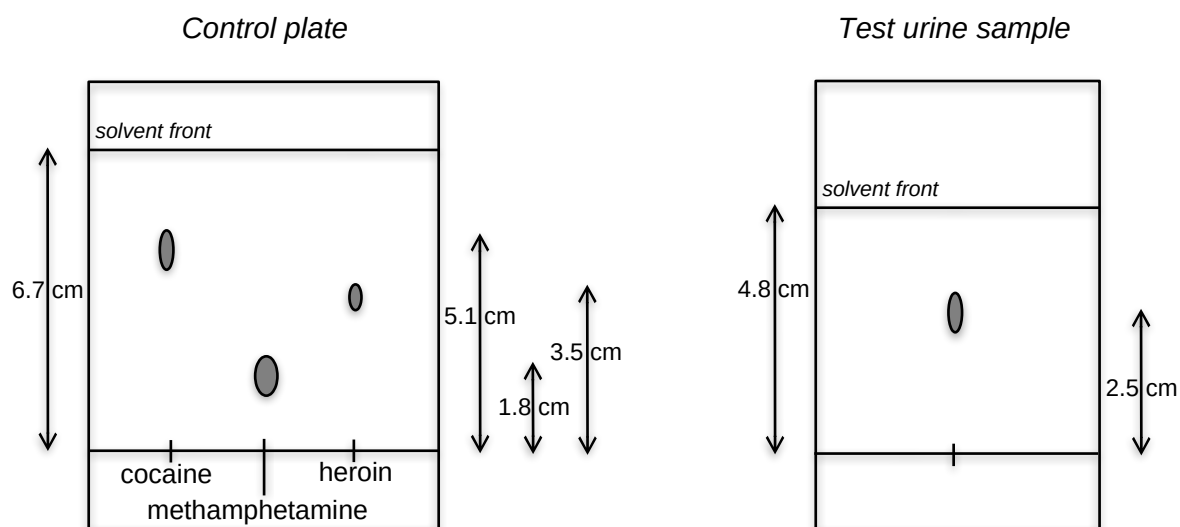
19. Consider the information in the table below.

Substance	Boiling point ($^{\circ}\text{C}$)
hexane	68
ethanol	78
water	100

Which substance would have the highest vapour pressure at 50°C ?

- (a) Hexane.
(b) Ethanol.
(c) Water.
(d) More information is required.
20. Which of the following statements is **not** correct, regarding the three allotropes of carbon; diamond, graphite and fullerenes?
- (a) Diamond is unable to conduct electricity.
(b) Fullerenes are classified as nanomaterials.
(c) Graphite is a covalent molecular substance.
(d) Buckyballs are examples of fullerenes.
21. Which of the following bonds would be the most polar?
- (a) N-Cl
(b) C-Cl
(c) H-Cl
(d) Li-Cl

22. One use of thin layer chromatography (TLC) is in the analysis of urine samples taken from professional athletes. TLC can be used to detect whether any illegal substances are present in the urine. Consider the two TLC plates below which have been run under identical conditions. On the left is a control plate, showing the markers for the illegal substances cocaine, methamphetamine and heroin. On the right is a test urine sample.

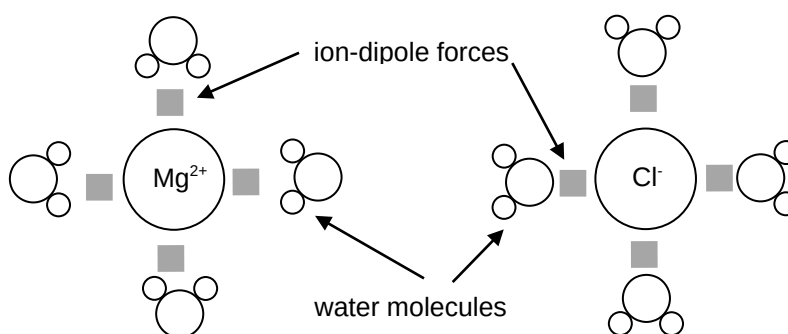


A chemist used retention factor (R_f) values to compare the urine sample to the control plate.

$$R_f = \frac{\text{distance travelled by the substance}}{\text{distance travelled by the solvent}}$$

Has the urine sample tested positive for any of the illegal substances?

- (a) Yes, cocaine.
 - (b) Yes, methamphetamine.
 - (c) Yes, heroin.
 - (d) No, none.
23. A student drew the following diagram to represent the formation of ion-dipole forces in a solution of magnesium chloride, $\text{MgCl}_2(\text{aq})$.



The diagram is **not** correct. Why?

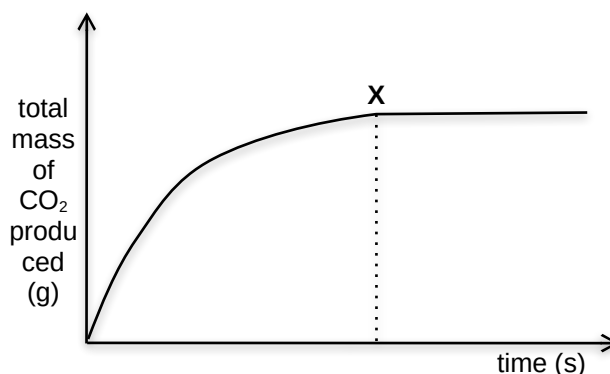
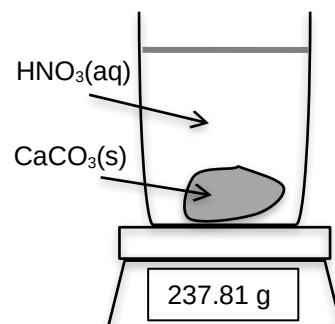
- (a) MgCl_2 is insoluble and does not dissociate in water.
- (b) This is not a situation in which ion-dipole forces are formed.
- (c) The cation and anion need to be swapped in this diagram.
- (d) There is no attraction between water molecules and ions.

Questions 24 and 25 relate to the information below.

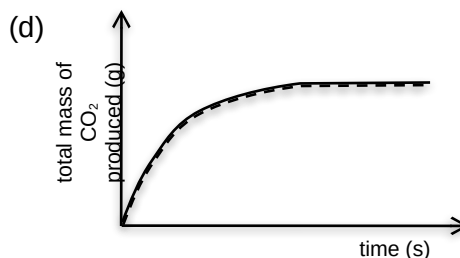
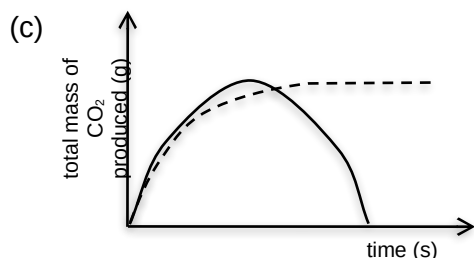
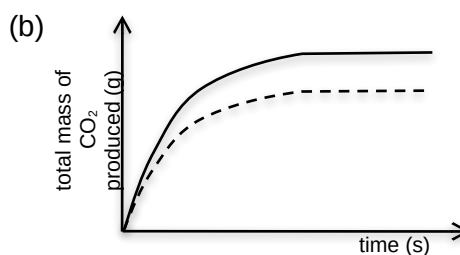
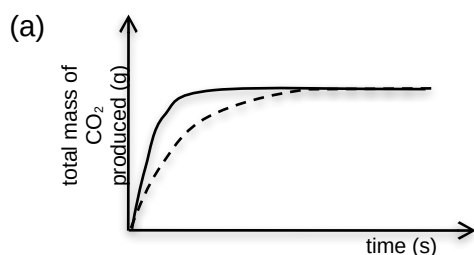
A chemistry class was investigating the reaction between calcium carbonate (CaCO_3) and nitric acid (HNO_3). They placed 2.0 g of CaCO_3 into a beaker containing **excess** $0.25 \text{ mol L}^{-1} \text{HNO}_3$. The beaker was on a balance so the mass could be monitored throughout the experiment.

The original mass of the beaker containing the CaCO_3 and HNO_3 was quickly noted and the students then recorded the mass of the beaker every 5 seconds thereafter, until the CaCO_3 had all been consumed and the reaction stopped.

As carbon dioxide gas (CO_2) was produced in the reaction, the mass of the beaker decreased over time and from this, the students were able to infer the mass of $\text{CO}_2(\text{g})$ that had been produced in the reaction. Their results are summarised in the graph below.



24. Which of the following statements is correct for time point X?
- (a) Collisions between reactant particles are now occurring half as frequently as initially.
 - (b) CO_2 gas is now being produced at the maximum rate.
 - (c) The rate of the reaction is now almost zero.
 - (d) The pH of the solution in the beaker is now neutral.
25. The experiment was then repeated using $0.5 \text{ mol L}^{-1} \text{HNO}_3$ (i.e. a higher concentration than originally used). How would the graph of 'time vs total mass of CO_2 produced' in this trial compare to the original graph? (The original graph is shown below as a dashed line.)



End of Section One

SEE NEXT PAGE

Section Two: Short answer

35% (70 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.

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.

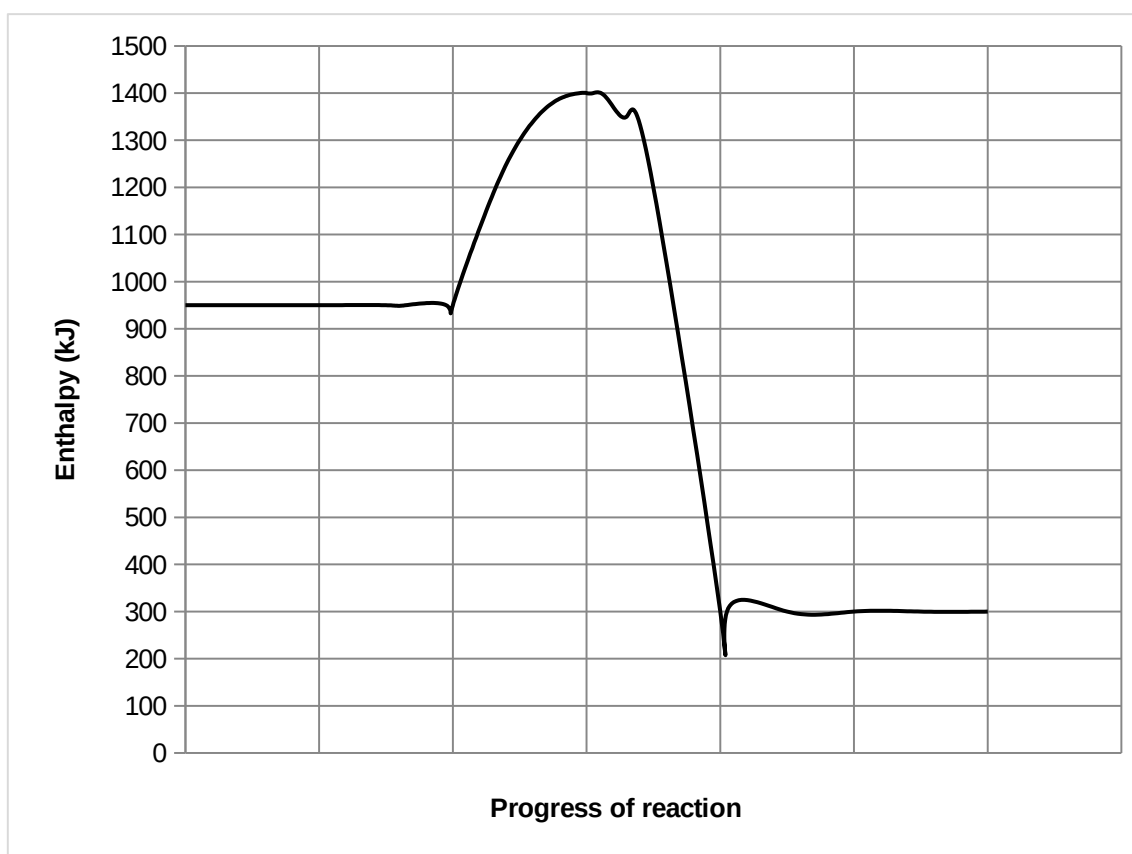
- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time: 60 minutes.

Question 26

(10 marks)

Consider the energy profile diagram shown below.



- (a) State the value of ΔH for this reaction and classify this reaction as endothermic or exothermic. (2 marks)

- (b) Explain how energy changes in bond breaking and bond formation relate to the overall change in enthalpy observed in this reaction. (2 marks)

- (c) Define 'activation energy' and state the value of E_a for this reaction. (2 marks)

There is much ongoing research into the use of nanomaterials as catalysts. When a metallic nanoparticle catalyst is used in the above reaction, the corresponding activation energy for this process is 300 kJ mol^{-1} .

- (d) Include this information on the energy profile diagram given. (1 mark)
- (e) Define the term 'nanomaterials'. What possible advantage could be provided by having the metal catalyst in nanoparticle form, rather than as a sheet or block of metal? (3 marks)

Question 27

(8 marks)

Explain each of the following scenarios that relate to the physical and chemical properties of water.

- (a) If you look at a spider web after a storm, you will often see that the rain has formed hundreds of tiny water beads clinging to the threads of the spider web, rather than a continuous film of water along the silk threads. (3 marks)

- (b) A child was adding table salt (NaCl) into a glass of water and watching it “disappear” as it dissolved. However, eventually the salt no longer dissolved and instead remained visible at the bottom of the glass. (2 marks)

- (c) Ethanol is soluble in water, whereas ethane is not soluble. (3 marks)

Ethanol	Ethane
$ \begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{OH} \\ \quad \\ \text{H} \quad \text{H} \end{array} $	$ \begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array} $
soluble	not soluble

Question 28**(10 marks)**

Consider the elements in Period 3 of the periodic table.

- (a) What property do all these elements have in common, that resulted in their position within Period 3 of the periodic table? (1 mark)

- (b) Which Period 3 element has the; (3 marks)

- (i) smallest atomic radius?

- (ii) highest electronegativity?

- (iii) lowest ionisation energy?

- (c) Explain why magnesium atoms form cations with a 2+ charge, but chlorine atoms form anions with a 1- charge. (4 marks)

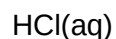
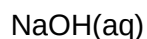
- (d) Define the term 'isotope' and name the Period 3 element which would be an isotope for an atom with the following subatomic particle arrangement. (2 marks)

protons = 15 neutrons = 15 electrons = 15

SEE NEXT PAGE

Question 29**(8 marks)**

Consider the eight (8) substances below. Using **only** these substances, answer the following questions by selecting appropriate substances from this list.



- (a) Explain, using the Arrhenius model and a chemical equation, why one of these substances is classified as a strong base. (2 marks)

- (b) Name two (2) substances that could be used to neutralise each other. (1 mark)

- (c) Write an equation for the reaction between two (2) substances that would produce a colourless, pungent-smelling gas when mixed. (2 marks)

- (d) What would be observed upon mixing CuCO₃(s) and HCl(aq)? (2 marks)

- (e) Name two (2) substances that when mixed would produce a gas that would test positive for the 'pop test'. (1 mark)

Question 30**(8 marks)**

Consider the two **incorrectly named** organic substances in the table below.

- (a) Draw structural diagrams, showing all bonds, for the organic substances named, and then give each its correct IUPAC name. (4 marks)

Incorrect name	Structural diagram	IUPAC name
1-methyl-3,3-dichlorobutane		
2-bromo-3-ethyl hex-4-ene		

The nature of the bonding within different hydrocarbons determines their chemical properties.

- (b) Explain why alkenes are able to undergo addition reactions but alkanes and benzene are not. (4 marks)

Question 31

(8 marks)

An empty balloon skin was found to weigh 3.7 g. It was then filled with 7.1 L of helium gas at STP.

- (a) Calculate the total mass of the balloon after filling. (3 marks)

- (b) Why does the helium balloon now float even though its total mass is greater? (1 mark)

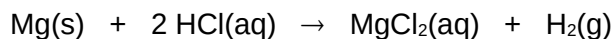
Explain the following in terms of the kinetic theory;

- (c) The pressure inside the balloon increased as helium gas was being pumped in. (2 marks)

- (d) The volume of the sealed balloon decreased when it was taken outside on a snowy day where the temperature was -8°C . (2 marks)

Question 32**(10 marks)**

Consider the reaction shown in the equation below.



- (a) For each of the individual substances in the equation above, complete the table below by stating; (4 marks)

- (i) the type of interatomic bonding present, and
(ii) whether or not each substance, when considered in isolation, would conduct electricity.

	(i) type of interatomic bonding present (i.e. metallic / ionic / covalent)	(ii) ability to conduct electricity (i.e. yes / no)
Mg(s)		
HCl(aq)		
MgCl ₂ (aq)		
H ₂ (g)		

- (b) Explain your answers to (a) part (ii) in terms of the structure and bonding present in the substances. Use equations to support your answer where appropriate. (6 marks)

SEE NEXT PAGE

Question 33

(8 marks)

A student was given the five (5) solutions listed below, each with a 0.05 mol L^{-1} concentration.

KOH

NaCl

H_2CO_3

HNO_3

NH_3

He then used universal indicator to determine the pH of each solution and plotted his results on the pH line shown.



(a) Complete the table below with the student's expected results.

(5 marks)

	Identity of substance	Colour in universal indicator
A		
B		
C		
D		
E		

(b) Name the substance that would have the highest concentration of H^+ ions.

(1 mark)

(c) Write successive ionisation equations to illustrate how H_2CO_3 behaves in water. **(2 marks)**

End of Section Two

SEE NEXT PAGE

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Section Three: Extended answer

40% (80 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.

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.

Suggested working time: 70 minutes.

Question 34

(16 marks)

Clean drinking water is essential in maintaining good health and hygiene and we are fortunate in Australia that sources of potable water are readily available to us. Water sourced from groundwater or seawater comprises most of the potable water in Perth. This water is subjected to extensive processing and monitoring before it reaches our homes to ensure its safety and quality are of the highest level.

One of the treatment steps performed on our potable water is 'fluoridation', which is done in accordance with the Department of Health to strengthen tooth enamel, thereby helping to prevent and minimise tooth decay in the general public. The amount of fluoride (F^-) present in our water supply is maintained at the recommended level of between 0.6 mg L^{-1} and 1 mg L^{-1} .

Fluoridation is performed by adding hexafluorosilicic acid (H_2SiF_6) into our water, which when dissolved, releases the fluorine contained within the compound as fluoride ions (F^-).

- (a) Calculate the percent composition by mass of fluorine in the compound hexafluorosilicic acid. (2 marks)

A tank containing 20 000 L of water was to be fluoridated by adding hexafluorosilicic acid. If 90.0 mL of $1.660 \text{ mol L}^{-1} \text{ H}_2\text{SiF}_6(\text{aq})$ was added to the tank and mixed thoroughly;

- (b) Calculate the concentration of fluoride ions (F^-) present in the water and state whether this falls within the range recommended by the Department of Health. (You may assume all the fluorine in the H_2SiF_6 is released into the water as fluoride ions.) (6 marks)

- (c) Other than fluoridation, name and briefly describe one other process our ground or sea water may be subject to, before joining the main water supply. (2 marks)

As well as processing and treating our water supply, the Water Corporation and Department of Health monitor our water to ensure that it does not include any contaminants such as heavy metals, which can be harmful to our health. The heavy metal lead, for example, can lead to a range of negative side effects when consumed in food or drinking water. These include cancer, stroke, kidney disease and high blood pressure.

The amount of lead present in a given sample of water can be accurately determined by atomic absorption spectroscopy (AAS). Analysis by AAS relies on knowledge of the absorption / emission spectrum of the element lead.

- (d) Describe how the absorption and emission spectrum of an element is related to electron energy levels, and how this is utilised in AAS. (6 marks)

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Question 35**(16 marks)**

Ethanol ($\text{C}_2\text{H}_5\text{OH}$) is an important chemical, which can be used as a fuel, solvent, antiseptic, in alcoholic beverages as well as in the manufacture of many other substances. One method of ethanol production is via the 'hydrolysis of ethene', which is an addition reaction between ethene gas and water vapour.

- (a) Write the equation for the 'hydrolysis of ethene' using structural diagrams for all organic substances. (1 mark)

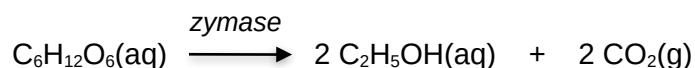
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This 'hydrolysis' reaction is carried out in a reaction chamber, at a pressure of 6000-7000 kPa and a temperature of 300 °C.

- (b) Explain, in terms of the collision theory, how each of these conditions increases the rate of reaction. (4 marks)

Pressure of 6000-7000 kPa	
Temperature of 300 °C	

A second method of ethanol production is via the fermentation of glucose by enzymes found in yeast. The glucose can be sourced from crops such as corn, wheat, potatoes and sugar cane. Ethanol produced by this method is called 'bioethanol'. The equation for the fermentation process is shown below;



- (c) Why are biofuels such as bioethanol considered more sustainable alternatives to fossil fuels? (2 marks)

- (d) Describe what an enzyme is and explain, in terms of the collision theory, the effect *zymase* has on the fermentation process. (4 marks)

When used as a fuel, the combustion of ethanol / bioethanol can be represented by the equation below.



Ethanol has a density of 0.789 kg L^{-1} . If 30.0 L of ethanol was to be combusted;

- (e) Calculate the volume of oxygen gas (at STP) that would be consumed in this reaction.
(4 marks)

- (f) Calculate the amount of heat energy that would be released in the combustion reaction described.
(1 mark)

Question 36**(17 marks)**

High performance liquid chromatography (HPLC) has many useful applications, with one of the most common being in the monitoring and analysis of additives used in food and beverages. A common additive found in many low calorie food and drink products is the artificial sweetener known as 'aspartame'. The safety of aspartame has been studied extensively over the years, with many people reporting side effects such as nausea, dizziness and abdominal pain. Whilst it is still classified as a 'safe substance' by various food and health organisations, many people choose to avoid aspartame consumption.

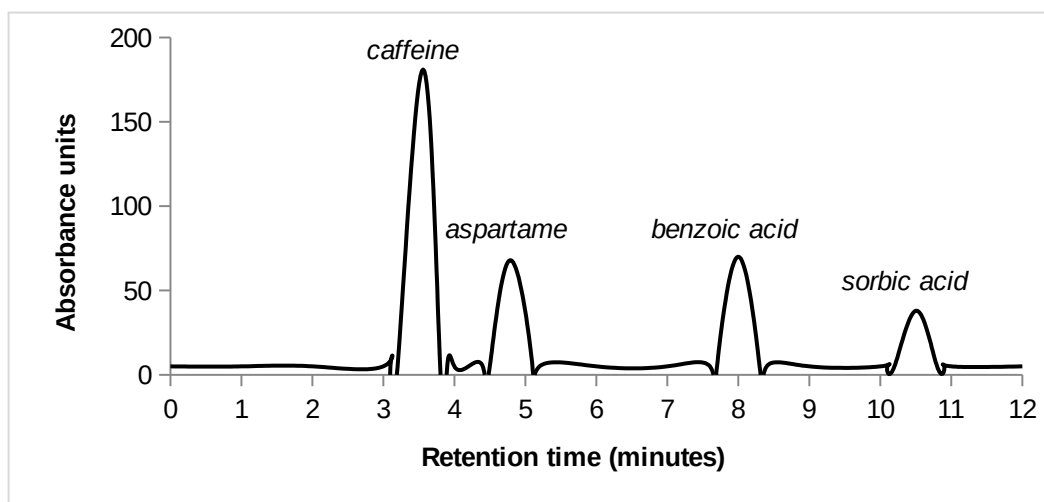
A chemist decided to run some tests to compare the aspartame levels found in four different types of soft drink, and she used HPLC to perform the analysis.

- (a) Discuss the chemical principles behind the process of HPLC by answering the following questions. (6 marks)

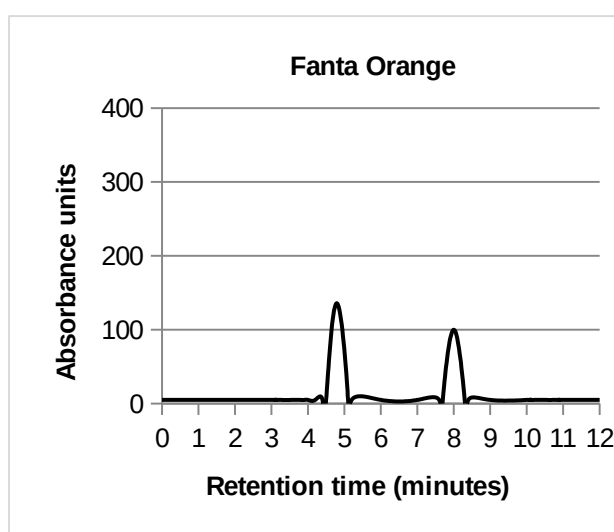
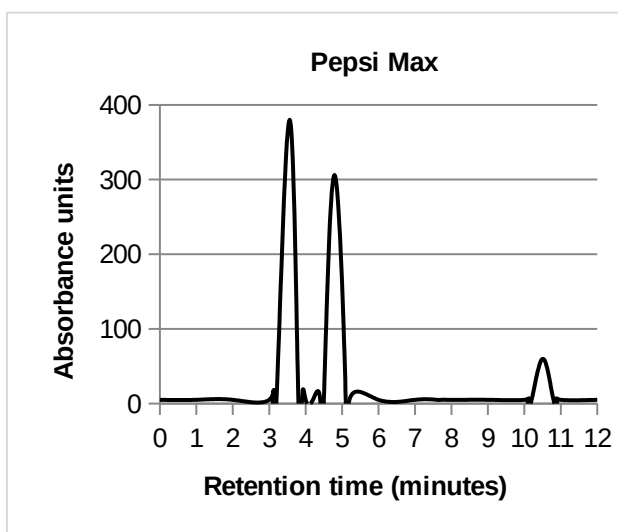
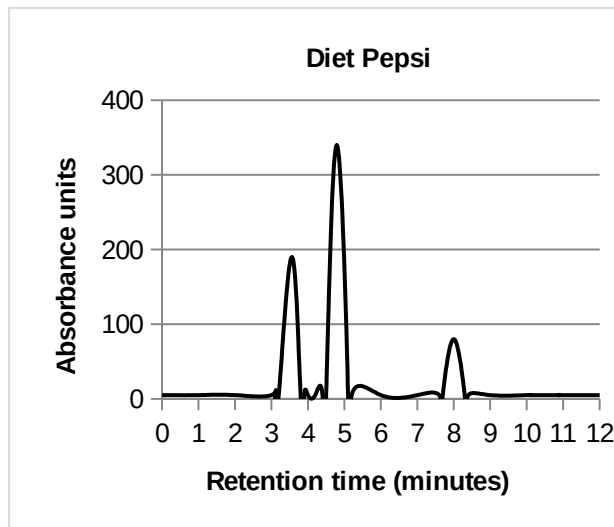
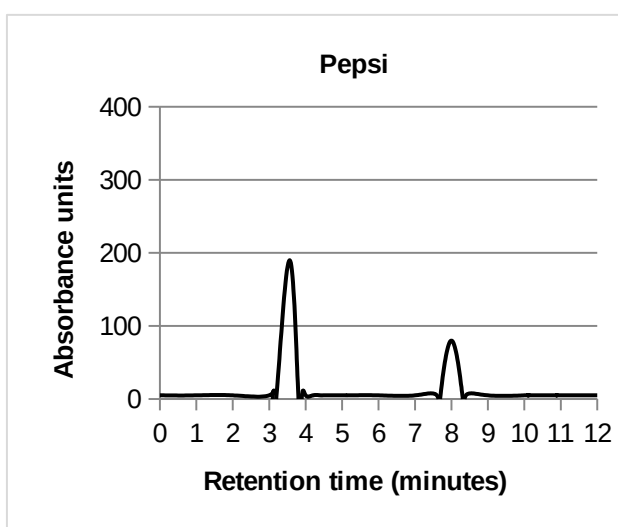
- (i) What physical properties must a sample have to make it appropriate for HPLC analysis to be used?

- (ii) Describe how HPLC is able to separate the components of a sample, in particular focussing on the role of polarity in the process.

The chemist used previous HPLC data to produce the 'control' chromatogram shown below, which displays the retention times for several common soft drink additives, including aspartame.



She then ran HPLC analysis on samples of four (4) different soft drinks; Pepsi, Diet Pepsi, Pepsi Max and Fanta Orange. The individual chromatograms for each soft drink are shown below. You may assume they were carried out under the same HPLC conditions as the 'control' above.

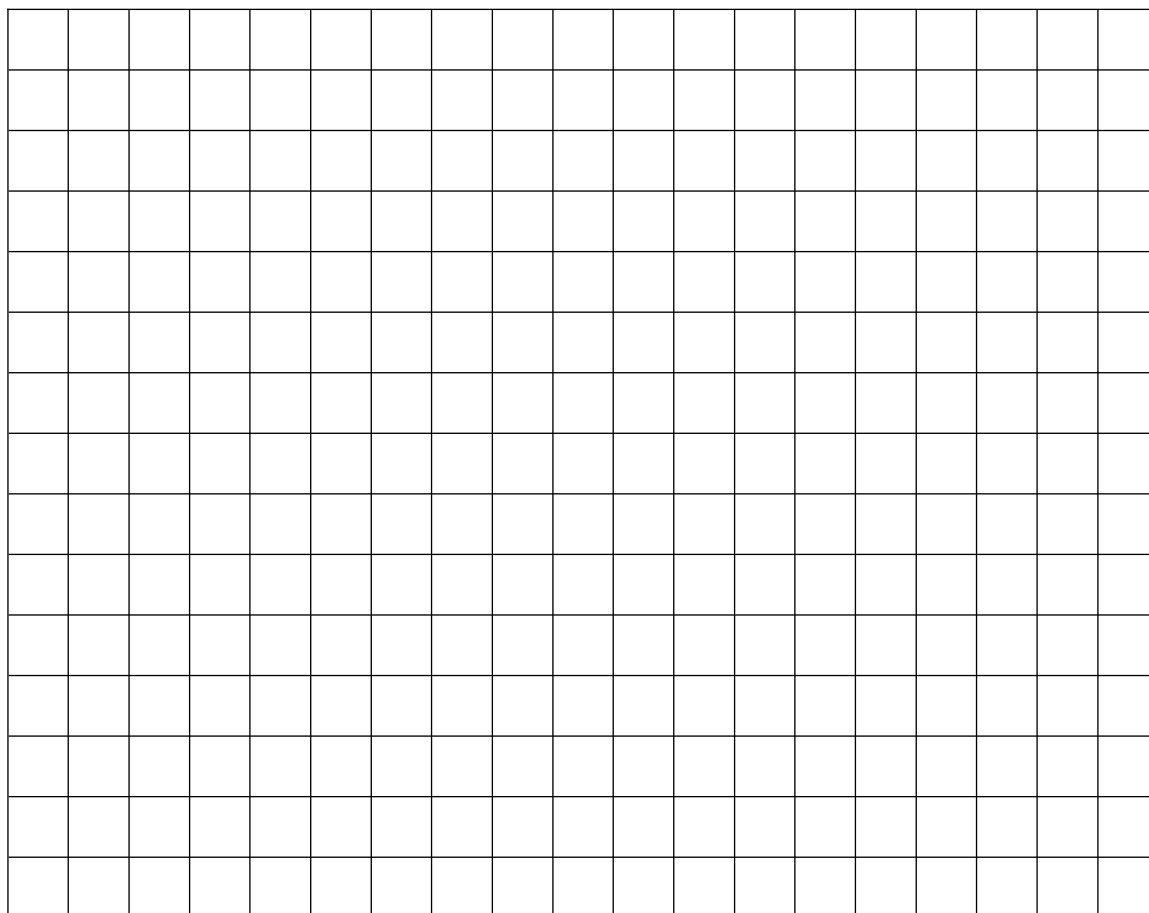


- (b) Which of the soft drinks contained aspartame? Name the drink with the highest aspartame concentration. (2 marks)

The chemist wanted to quantify her data, so she ran HPLC on a series of aspartame standards to produce a calibration curve. The results obtained from this are summarised in the table below.

Aspartame concentration (g L ⁻¹)	Absorbance units
0.1	70
0.2	135
0.3	200
0.6	410

- (c) Plot the calibration curve for aspartame on the grid below. (4 marks)



- (d) List two (2) controlled variables the chemist would have had to consider when performing HPLC on the various aspartame standards. (2 marks)

- (e) Use the information from the chromatograms and the calibration curve to calculate the concentration of aspartame (in mol L^{-1}) in the drink Pepsi Max. (Note: The molar mass of aspartame is 294.3 g mol^{-1} .) (3 marks)

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Question 37

(16 marks)

A group of chemistry students were given four (4) aqueous nitrate solutions with which to investigate some patterns of solubility. Each nitrate solution had a concentration of 0.25 mol L^{-1} . The solutions in question were;

potassium nitrate
 $\text{KNO}_3(\text{aq})$

nickel nitrate
 $\text{Ni}(\text{NO}_3)_2(\text{aq})$

silver nitrate
 $\text{AgNO}_3(\text{aq})$

calcium nitrate
 $\text{Ca}(\text{NO}_3)_2(\text{aq})$

The students were then given two (2) more solutions to help with the investigation;

sodium chloride
 $0.5 \text{ mol L}^{-1} \text{NaCl}(\text{aq})$

and

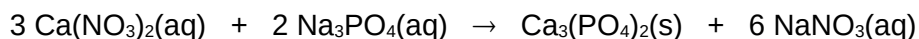
sodium phosphate
 $0.5 \text{ mol L}^{-1} \text{Na}_3\text{PO}_4(\text{aq})$

To study the solubility patterns, the students added a few drops of sodium chloride, $\text{NaCl}(\text{aq})$ to each of the four (4) nitrates and recorded their results. They then added a few drops of sodium phosphate, $\text{Na}_3\text{PO}_4(\text{aq})$ to separate samples of the four (4) nitrates and recorded these results.

- (a) Prepare a neat table that the students could use to record the data collected from this experiment. Complete the table by indicating 'PPT' if a precipitate is formed or 'NR' if no precipitate was observed. (4 marks)

- (b) Write the ionic equation and corresponding observation for the only precipitation reaction that would have occurred when NaCl(aq) was added to the nitrate solutions. (2 marks)

The precipitate formed from the reaction of Na₃PO₄ with Ca(NO₃)₂ was taken for further analysis. The molecular equation for this precipitation reaction is given below.



- (c) If 10 drops of 0.5 mol L⁻¹ Na₃PO₄(aq) had been added to the sample containing excess 0.25 mol L⁻¹ Ca(NO₃)₂(aq), what mass of precipitate would you expect to produce? You may assume one drop is equal to a volume of 0.05 mL. (4 marks)

The students decided to isolate the $\text{Ca}_3(\text{PO}_4)_2$ precipitate from the reaction vessel and weigh it to determine if the actual mass matched their theoretical calculated value.

- (d) List the steps that could be used by the students to obtain the $\text{Ca}_3(\text{PO}_4)_2$ precipitate for weighing. (4 marks)

The students found that once they collected and weighed the $\text{Ca}_3(\text{PO}_4)_2$ precipitate, the mass was slightly lower than that predicted by their calculation.

- (e) State one potential source of both random and systematic error in their investigation that may have lead to this discrepancy. (2 marks)

Random error	
Systematic error	

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(15 marks)

The table below summarises information regarding the boiling points of three (3) covalent molecular substances; ammonia (NH_3), methane (CH_4) and hydrogen sulfide (H_2S).

	Ammonia NH ₃	Methane CH ₄	Hydrogen sulfide H ₂ S
Boiling point (°C)	-33	-161	-60
Lewis structure diagram			
Molecular shape			

- (a) Complete the table above by drawing Lewis structure diagrams for each of the molecules, as well as stating the molecular shape as predicted by the VSEPR theory. Include all bonding and non-bonding electron pairs in your Lewis diagrams. (6 marks)
- (b) Discuss the reasons for the different boiling points of these three substances. (6 marks)

[illegible]

A 5.78 g sample of one of these 3 gaseous substances had its volume measured at STP and was found to occupy 3.85 L.

- (c) Identify which of the compounds this gas was, showing all calculations. (3 marks)

End of questions

SEE NEXT PAGE

Spare answer page

Question number: _____

Spare answer page

Question number: _____

