Insert School Logo

CHEMISTRY

UNIT 1

2018

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	10	10	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.

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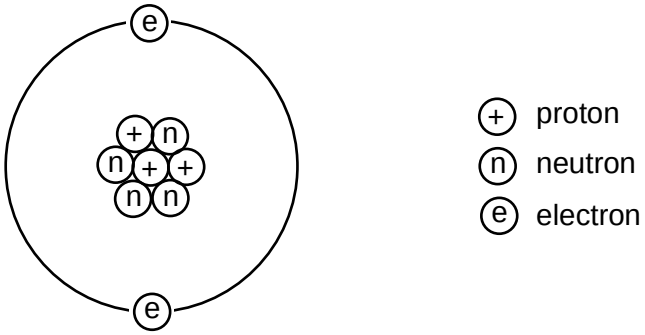
1. What is the identity of this species?



(a) Helium atom
(b) Lithium atom
(c) Helium ion
(d) Lithium ion

2. Covalent substances are generally not able to conduct electricity because

(a) their electrons are localised.
(b) their electrons are delocalised.
(c) their electrons are transferred.
(d) their electrons are shared.

3. Which of the following is **not** an example of how a nanomaterial differs from its bulk material form?

(a) Nanoparticles of gold appear pink in colour.
(b) Nanoparticles of ZnO are invisible.
(c) Nanoparticles of ZnS are soluble in water.
(d) Nanoparticles of silver conduct electricity.

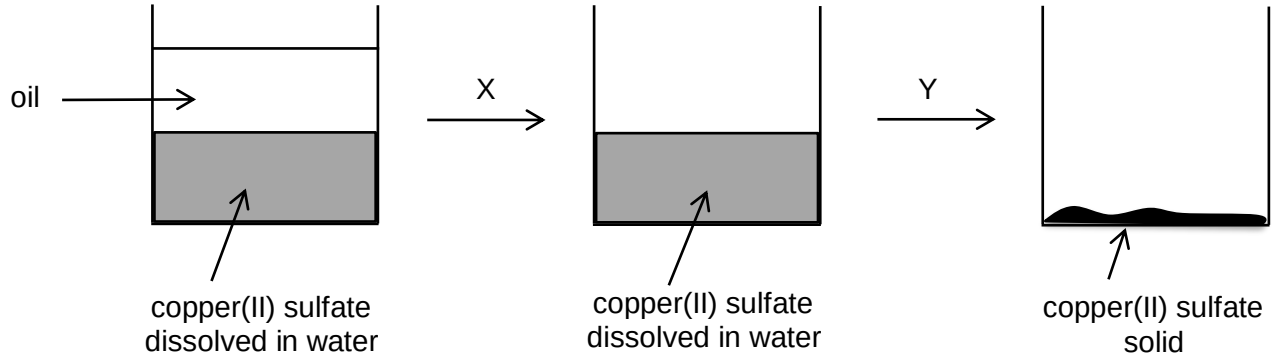
4. Which of the following formulas represents a substance that contains twice as much hydrogen as oxygen, and half as much carbon as oxygen?

(a) $C_4H_8O_6$
(b) $C_2H_6O_3$
(c) $C_3H_{12}O_6$
(d) $C_5H_{10}O_3$

5. Which of the following is **not** a pure substance?

(a) Ammonia
(b) Cobalt chloride
(c) Salt water
(d) Sulfur trioxide

A beaker contained a mixture of copper(II) sulfate, water and oil, as shown in the diagram below. It was separated in a series of steps, as indicated in the diagram.



6. What are the names of the processes, X and Y, used to perform these separation steps?

	X	**Y**
(a)	filtration	evaporation
(b)	filtration	decantation
(c)	decantation	filtration
(d)	decantation	evaporation

7. Which element is found in group 15, period 5?

(a) Tin
(b) Antimony
(c) Polonium
(d) Bismuth

8. How many electrons are in the valence shell of the following species?

	Mg	**Al^{3+}**	**O^{2-}**	**P**
(a)	2	3	6	5
(b)	2	8	8	5
(c)	1	6	4	8
(d)	2	0	8	8

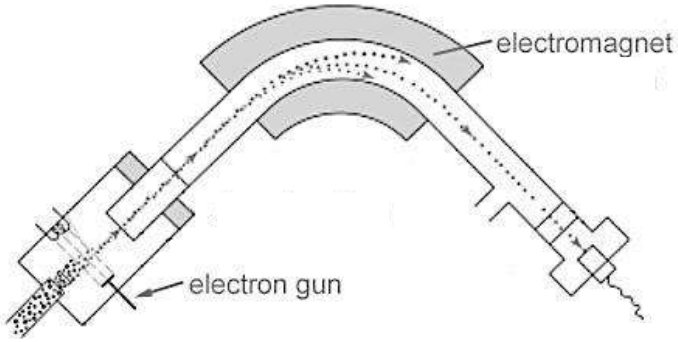
9. Which of the following isotopes is likely to be the **least** commonly occurring?

(a) carbon-12
(b) sulfur-32
(c) iron-55
(d) nitrogen-16

10. Which of the formulas below is **incorrect**?

(a) Ba_2F
(b) CaS
(c) Na_3P
(d) $AlCl_3$

11. The following is a simplified diagram showing how a mass spectrometer works. When a sample is analysed by mass spectrometry, it undergoes a series of four (4) steps.



For which of the four steps is the electromagnet responsible?

(a) Ionisation
(b) Acceleration
(c) Deflection
(d) Detection

12. Which of the following substances is **not** able to conduct electricity?

(a) NaCl(aq)
(b) Au(s)
(c) KF(s)
(d) Hg(l)

13. Which of these chemical equations represents an exothermic reaction?

(i) $CO + H_2O \rightarrow H_2 + CO_2 + 41\ kJ$
(ii) $CH_4 + H_2O \rightarrow CO + 3\ H_2 \quad \Delta H = +206\ kJ$
(iii) $N_2O_3 + 40\ kJ \rightarrow NO + NO_2$

(a) (i) only
(b) (ii) only
(c) (iii) only
(d) (ii) and (iii) only

14. Which of these organic compounds has a different molecular formula to the others?

(a) oct-3-ene
(b) 2,3,3-trimethylpent-1-ene
(c) 3-ethylhept-2-ene
(d) 3,4-dimethylhex-3-ene

15. Element X is in group 16 of the periodic table. Which of the following compounds is **least** likely to form?

(a) H_2X
(b) NaX
(c) MgX
(d) F_2X

16. Ionic substances are brittle because

(a) electrons have been transferred between species.
(b) electrons are shared between species.
(c) they are solids at room temperature.
(d) the charged species are arranged in a rigid lattice.

17. Which of these is **not** a correct IUPAC name?

(a) 2,2-dichloropent-3-ene
(b) 2-methylbut-1-ene
(c) methylpropane
(d) 1,2,2-tribromohexane

18. What are the coefficients in this equation once correctly balanced?

$$\_\_\_\ NH_3(g) + \_\_\_\ O_2(g) \rightarrow \_\_\_\ NO(g) + \_\_\_\ H_2O(l)$$

(a) 2, 2, 2, 3
(b) 1, 3, 1, 2
(c) 4, 2, 3, 5
(d) 4, 5, 4, 6

19. What is the name given to the elements in group 17?

(a) Halogens
(b) Alkali metals
(c) Alkaline earth metals
(d) Noble gases

20. Which of the following could **not** result in a substitution reaction?

(a) propane mixed with chlorine water
(b) benzene mixed with aqueous iodine
(c) pent-1-ene mixed with bromine water
(d) chloromethane mixed with aqueous chlorine

21. Which of the following contains the greatest number of **atoms**?

(a) 3.0 g of Pb
(b) 0.01 mol of Ca
(c) 0.005 mol of NaCl
(d) 0.28 g NO_2

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22. Which of the following are covalent compounds?

(i) Hydrogen peroxide
(ii) Carbon monoxide
(iii) Potassium hydroxide
(iv) Copper(II) phosphate
(v) Sulfurous acid

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

Questions 23, 24 and 25 relate to three common allotropes of carbon; diamond, graphite and fullerenes.

Consider the list of physical properties given below.

(i) Conductor of electricity
(ii) High melting point
(iii) Hard substance
(iv) Inert (unreactive) substance
(v) Atoms form a three dimensional network shape

23. Which of these properties correspond to diamond?

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

24. Which of these properties correspond to graphite?

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

25. The most significant property that distinguishes fullerenes from both diamond and graphite is their

(a) electrical conductivity.
(b) size.
(c) elemental composition.
(d) strength.

End of Section One

Section Two: Short answer **35% (70 marks)**

This section has **10** 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.

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Suggested working time: 60 minutes.

Question 26 **(6 marks)**

Two sulfur-containing compounds that have very different properties are aluminium sulfate ($Al_2(SO_4)_3$) and sulfuric acid (H_2SO_4). Explain, in terms of structure and bonding, why aluminium sulfate is a solid at room temperature, whereas pure sulfuric acid is an oily liquid.

Question 27 **(8 marks)**

(a) Complete the table below by; (6 marks)

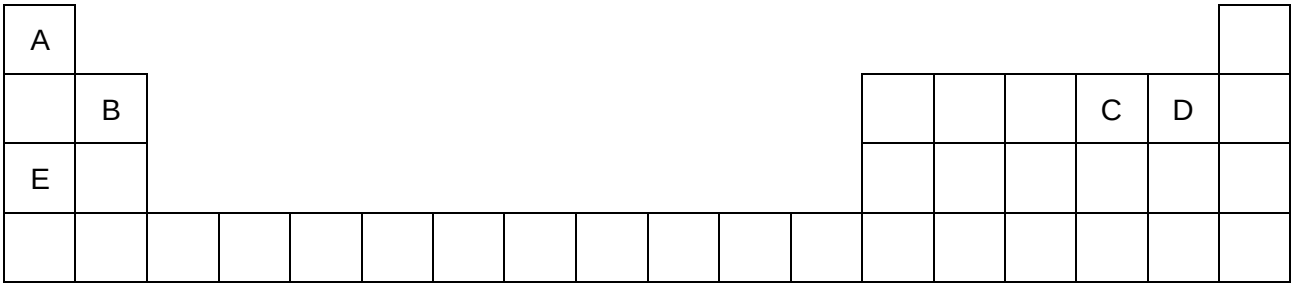
- drawing structural formulas showing **all bonds and atoms**, and
- writing the molecular formula for each organic molecule.

	Structural diagram	Molecular formula
2,2,3-trimethylbutane		
3-ethylpent-2-ene		
methylbenzene		

(b) Which of the organic compounds above contains the highest percentage of carbon by mass? Calculate this value. (2 marks)

Question 28 **(8 marks)**

Consider the elements labelled A-E on the diagram below, which shows the first four periods of the periodic table.



(a) Why are A and E both in group 1? (1 mark)

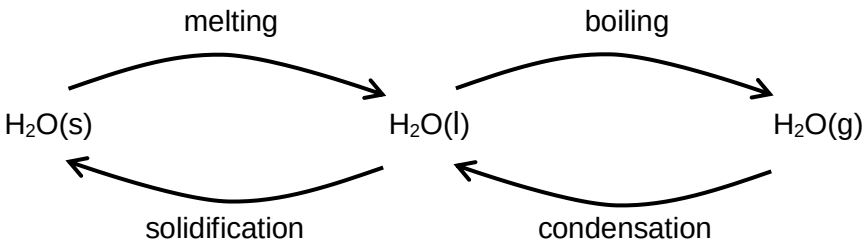
(b) Why are B, C and D all in period 2? (1 mark)

(c) Why would atoms of element C and E form chemical bonds? State the type of compound formed and describe how the chemical bonds form. (3 marks)

(d) Why would atoms of element C and D form chemical bonds? State the type of compound formed and describe how the chemical bonds form. (3 marks)

Question 29 **(6 marks)**

Consider the diagram below.



(a) Name one (1) of the labelled phase changes that is **endothermic**. Justify your choice. (3 marks)

Bioluminescent Bay in Puerto Rico is a popular tourist attraction because of the microorganisms that live in the water. These types of organisms glow in the dark because they produce light by a special chemical reaction.

(b) Explain why this reaction is exothermic. (3 marks)

Question 30 **(8 marks)**

All matter can be classified as either pure substances or mixtures.

(a) Complete the table below by writing the name or formula of the compound, as well as classifying the compound as having consistent properties with either an ionic or covalent substance. (6 marks)

Name	Formula	Covalent or ionic properties
Ammonium carbonate		
	$Fe(NO_3)_3$	
Ethanoic acid		

The table above refers only to pure substances.

(b) State two (2) ways a mixture differs from a pure substance. (2 marks)

_____

_____

_____

_____

Question 31 **(7 marks)**

Complete the table below, showing the subatomic particle arrangement of the four different species.

Symbol	Number of protons	Number of neutrons	Electron configuration
^{19}F			
	11	12	2, 8
$^{32}S^{2-}$		16	
	6	8	2, 4

Question 32 **(7 marks)**

Salts containing the metal potassium (K) have a characteristic lilac (purple) colour in a flame test. A chemistry student was planning on performing flame tests on a series of different salt samples, trying to find one that contained a rare isotope of potassium. However, the student decided that the flame test would not be reliable as the isotope flame colour would be different from usual.

(a) What is an isotope? (2 marks)

(b) Was the student correct? Explain. (3 marks)

The relative atomic mass (Ar) of potassium is 39.10.

(c) What is the Ar of an element? What does it indicate that the Ar of potassium is close to the whole number of 39? (2 marks)

Question 33 **(9 marks)**

Nanosilver is an example of a nanomaterial and refers to an extremely finely divided form of silver. Nanosilver is used widely due to its ability to function as an antibiotic and disinfectant.

(a) What is a nanomaterial? (2 marks)

Despite its beneficial qualities, there may be potential negative side effects from the use of nanosilver. Some people who have been exposed to high levels of silver, for example in certain medications, have developed a condition where their skin turns blue.

(b) Why are all products containing nanomaterials carefully monitored? (2 marks)

It is thought that the antibacterial properties of nanosilver occur when silver ions (Ag^+) are released by the silver nanoparticles.

(c) What is an ion? Explain how a silver ion forms. (3 marks)

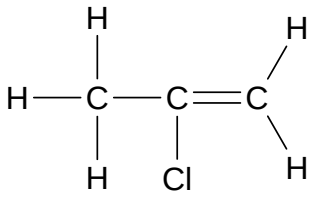
A nurse used a bandage coated with 0.0837 g of nanosilver to cover a serious burn on a patient's arm and prevent it becoming infected.

(d) Calculate the number of atoms of silver present on the bandage. (2 marks)

Question 34 **(5 marks)**

Complete the reactions below by drawing structural formulas or naming the substances as required.

(a)



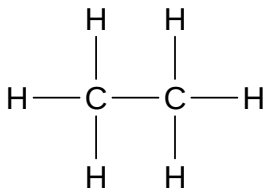
+ Br_2 →

Structural formula:

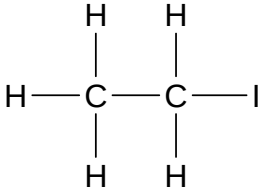
Name:

Name:

(b)



+ I_2 →



+

Formula:

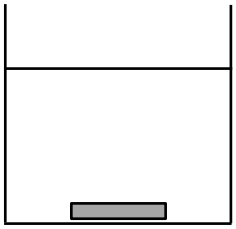
Name:

Question 35 **(6 marks)**

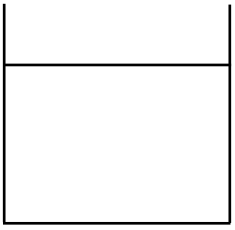
A student was conducting an experiment on the reaction between magnesium metal (Mg) and hydrochloric acid (HCl). Her experimental set up is shown below, as well as the measurements that she made during the investigation.

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

Start of experiment – Mg mixed with HCl



End of experiment – all Mg dissolved



Mass of empty beaker	34.5 g
Mass of Mg added	8.9 g
Mass of HCl added	43.1 g
Total mass of beaker at start of experiment	

Total mass of beaker at end of experiment	85.8

(a) State the Law of Conservation of Mass and use this law to calculate the mass of hydrogen gas produced in this experiment. You may assume the acid was in excess and all of the magnesium reacted. (3 marks)

(b) If 8.9 g of magnesium was used in the experiment, as stated above, calculate the mass of hydrochloric acid that would have been consumed. (3 marks)

End of Section Two

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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.

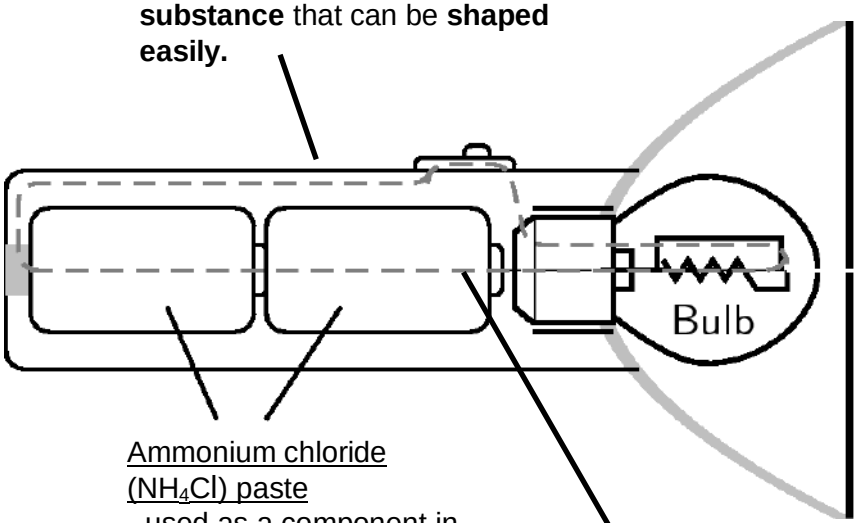
Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- 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 36 **(14 marks)**

Study the following diagram of a torch (flashlight). Several components have been labelled and some information about the properties of these materials has also been included.



Plastic ($(C_2H_4)_x$)
- used to make the body of the torch because it is a **soft substance** that can be **shaped easily.**

Glass / Silicon dioxide (SiO_2)
- used to protect the bulb because it is **hard** and **strong.**

Ammonium chloride (NH_4Cl) paste
- used as a component in batteries because it **conducts electricity.**

Copper (Cu)
- used for the wiring because it is **malleable** and **conducts electricity.**

Explain why each of the labelled materials has been used in this torch. Your answer should focus on the type of bonding present in each of the four (4) labelled components, as well as an explanation of their main properties (shown in **bold**), in terms of the structure and bonding present.

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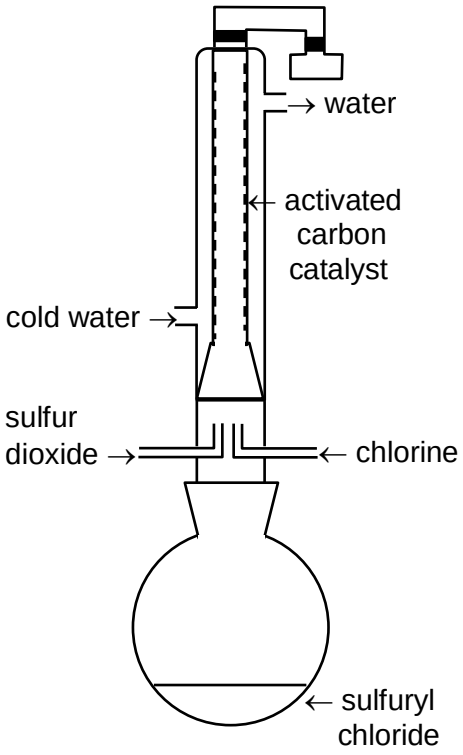
Question 37 **(15 marks)**

Sulfuryl chloride is a toxic, corrosive substance with a pungent odour. It isn't found in nature because it reacts quickly with water to produce a mixture of hydrochloric and sulfuric acids. Some information on sulfuryl chloride is shown in the table below.

Formula	SO_2Cl_2
Melting point	-54.1 °C
Boiling point	69.4 °C
Density	1.67 g mL^{-1}



Sulfuryl chloride can be made using the apparatus shown in the diagram to the right. **Sulfur dioxide** and **chlorine gases** are added into the glass reaction vessel. Here they react to form **sulfuryl chloride**. The inner tube of the reaction vessel is coated with an **activated carbon (C) catalyst**. This reaction is **exothermic**, so cold water is used to cool the glass reaction vessel and keep the temperature at around 30-40 °C.

(a) What phase (state) would sulfuryl chloride be when it forms, if the temperature of the reaction vessel is kept to around 30-40 °C? Justify your answer. (2 marks)

(b) Write a balanced molecular equation for the synthesis of sulfuryl chloride, as described in the reaction above. Include all **bolded** information, as well as phase (state) symbols, in your equation. (4 marks)

See Next Page

(c) If 87.5 g of sulfur dioxide gas is added into the reaction vessel, what is the maximum mass of sulfuryl chloride that could be produced? (3 marks)

Once sulfuryl chloride is produced, it is separated from the reaction mixture by distillation. This is done by heating the reaction vessel to 68-70 °C and collecting the sulfuryl chloride fraction.

(d) Sketch a labelled diagram below showing the apparatus used for distillation. (4 marks)

(e) Why is a temperature of 68-70 °C chosen to separate the sulfuryl chloride during the distillation process? (2 marks)

Question 38 **(19 marks)**

Three groups of chemistry students (A, B and C) were investigating endothermic and exothermic reactions. Each group was given one reaction to study, as shown in the table below.

Group A	$HCl(aq) + NaHCO_3(aq) \rightarrow NaCl(aq) + CO_2(g) + H_2O(l)$
Group B	$CuSO_4(aq) + Mg(s) \rightarrow MgSO_4(aq) + Cu(s)$
Group C	$Ba(OH)_2(s) + 2\ NH_4SCN(s) \rightarrow Ba(SCN)_2(aq) + 2\ H_2O(l) + 2\ NH_3(g)$

Each group planned their experiment, with the aim to investigate whether their reaction was endothermic or exothermic. They mixed their reagents together in test tubes and recorded the initial temperature of the system, as well as the final temperature once the reaction was finished.

The incomplete results of each group are shown in the tables below.

Group A	**Trial 1**	**Trial 2**	**Trial 3**
Initial temp (°C)	20.5	20.0	21.5
Final temp (°C)	17.0	16.0	18.0
Temperature change (°C)	- 3.5		

Group B	**Trial 1**	**Trial 2**	**Trial 3**
Initial temp (°C)	22.5	21.5	23.0
Final temp (°C)	25.0	26.5	26.5
Temperature change (°C)	+ 2.5		

Group C	**Trial 1**	**Trial 2**	**Trial 3**
Initial temp (°C)	18.5	19.0	19.5
Final temp (°C)	4.0	5.5	
Temperature change (°C)	-14.5		

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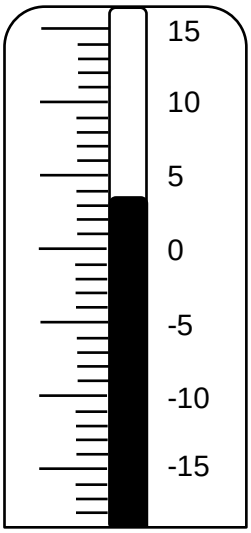
The final temperature reading of group C is shown on the thermometer to the right.



(a) Complete the tables on the previous page, by reading the final result for group C and recording it in the correct table. Then fill in any other values that are missing, by calculating the change in temperature (i.e. final – initial). (4 marks)

The following diagrams represent the energy changes that can occur during a reaction, as well as illustrate whether a reaction is endothermic or exothermic.

Diagram X

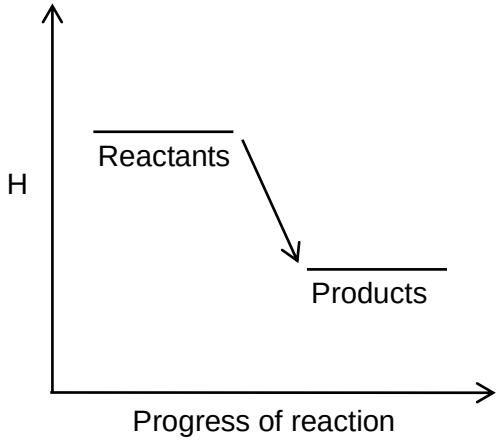
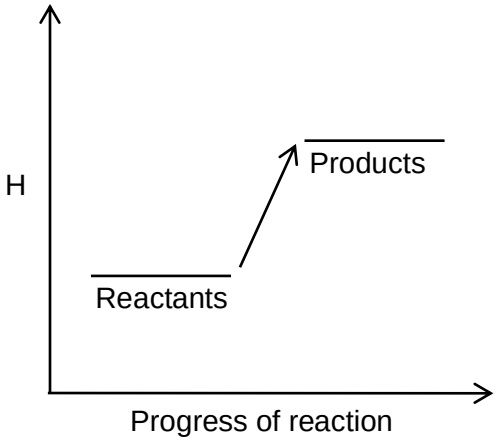


Diagram Y



Choose **one** of the reactions investigated (A, B or C) that corresponds to Diagram X.

(b) State the reaction (A, B or C) and explain what information this diagram provides in terms of the bond breaking and bond making that has occurred in your chosen reaction. (3 marks)

Choose **one** of the reactions investigated (A, B or C) that corresponds to Diagram Y.

(c) State the reaction (A, B or C) and explain why this diagram represents your chosen reaction. Include a description of how the Law of Conservation of Energy relates to this diagram. (4 marks)

(d) Explain why the groups would have chosen to carry out three trials. (2 marks)

(e) Which group had the most **precise** results? Justify your answer and explain the difference between precise and accurate. (3 marks)

Group B realised that they had forgotten to 'tare' (reset to zero) the balance they used to weigh out the magnesium metal. This resulted in them using **less** Mg(s) than intended in each trial.

(f) Is this a random or systematic error? Justify your choice and state the likely effect that this error would have had on the final temperatures that group B measured (i.e. higher, lower or unchanged)? (3 marks)

Question 39 **(19 marks)**

Diesel is a fuel that can be obtained from crude oil. It is used in most forms of transport, from trucks, cars and tractors to aircraft and rail cars. Biodiesel is most commonly produced from vegetable oil in a chemical reaction called transesterification. It can be used in pure form, in many of the same vehicles as regular diesel, however it is often used as a biodiesel-diesel mix.

(a) Briefly describe two (2) advantages of using biofuels instead of fossil fuels as an energy source. (2 marks)

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(b) State two (2) reasons it is not always possible for people to use biofuels. (2 marks)

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The table below gives some information regarding diesel and biodiesel.

	Formula	Molecular weight (M)	Energy output (MJ kg^{-1})
Diesel	$C_{18}H_{34}$		44.98
Biodiesel	$C_{18}H_{36}O_2$		38.48

(c) Complete the table by calculating the molecular weight (M) of each fuel. (2 marks)

(d) Calculate the energy output of **diesel** in kilojoules per mole (kJ mol^{-1}).
Note: 1 MJ = 1 x 10^6 J. (4 marks)

The equation for the combustion of **biodiesel** is shown below.

$$C_{18}H_{36}O_2(l) + 26\ O_2(g) \rightarrow 18\ CO_2(g) + 18\ H_2O(l) + 10946\ kJ$$

If a sample of biodiesel was combusted and 7.045 tonnes of $CO_2(g)$ was released into the atmosphere;

(e) Calculate the mass of biodiesel that would have been consumed. Express your answer to the appropriate number of significant figures. (5 marks)

(f) Calculate the amount of energy released. (2 marks)

(g) What mass of **diesel** would have been needed to release this same amount of energy? (2 marks)

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Question 40 **(13 marks)**

Meteorites that hit the Earth's surface can provide scientists with information about the chemical composition of objects in different parts of our solar system or galaxy. A sample of ice was taken from a meteorite that landed in the Australian outback, and the extra-terrestrial water was analysed to determine the presence of various elements.

Atomic absorption spectroscopy (AAS) was used to determine the presence and concentration of various elements in the extra-terrestrial water, including silicon. AAS is an effective technique because each element has it's own characteristic absorption / emission spectrum.

(a) Explain how electron absorption / emission spectra are related to the electron shells (levels) of an element. (4 marks)

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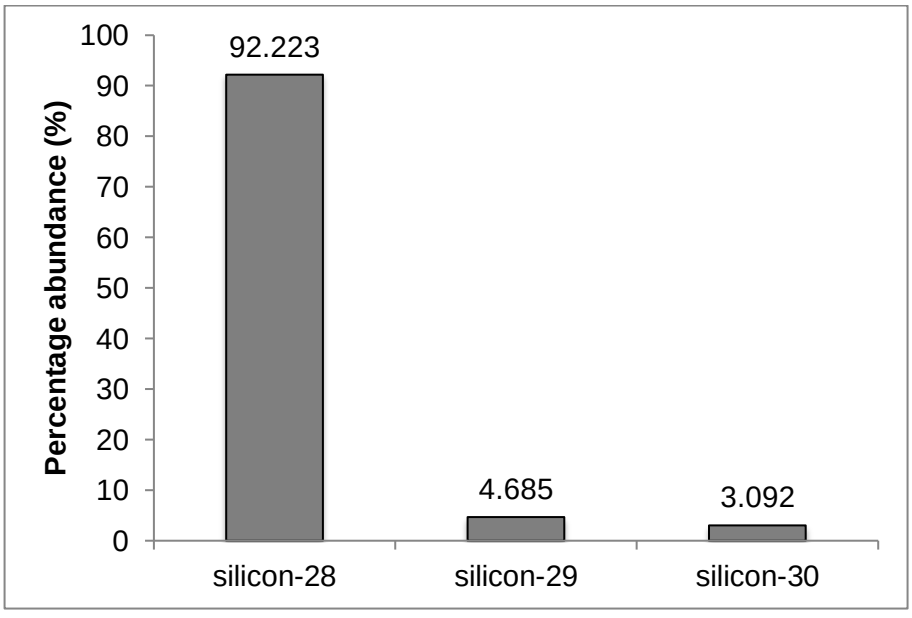
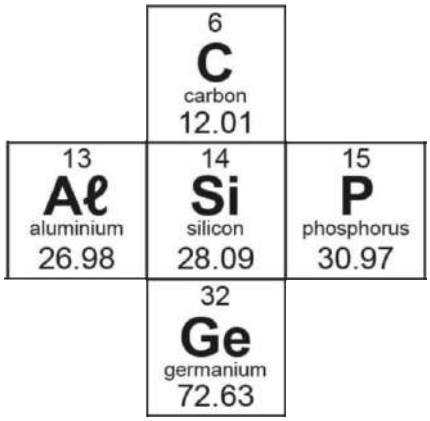
AAS determined that there was some silicon present in the extra-terrestrial water. Some of the silicon sample was isolated and sent for analysis by mass spectrometry, to determine if the isotopic forms of this silicon were the same as those found on Earth.

The results of the mass spectrometry are shown below.



(b) Calculate the relative atomic mass (Ar) of this extra-terrestrial silicon, and comment on its similarity to the silicon found on Earth. (3 marks)

A portion of the periodic table, showing the elements surrounding silicon, is given below. Consider the five elements in the diagram.



(c) Of these elements, germanium has the largest atomic radius and the smallest first ionisation energy. Explain why. (3 marks)

(d) Define electronegativity, and state and explain the trend in electronegativity as you move left to right from aluminium to phosphorus. (3 marks)

End of questions

Spare answer page

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Acknowledgements

Question 11 *Source: http://scienceaid.co.uk/chemistry/fundamental/particles.html*

Question 36 *Source: OpenStax, Physics - grade 10 [caps 2011]. OpenStax CNX. Jun 14, 2011 Download for free at http://cnx.org/content/col11298/1.3*