METHODIST LADIES' COLLEGE

Methodist Ladies' College
Semester 1 Examination, 2016

Question/Answer Booklet

CHEMISTRY
ATAR Year 11

Student Name: _____

Teacher Name: _____

Time allowed for this paper
Reading time before commencing work: ten minutes
Working time for paper: 2.5 hours

Materials required/recommended for this paper
To be provided by the supervisor
This Question/Answer Booklet
Multiple-choice Answer Sheet
Chemistry Data Sheet

Number of additional answer booklets used (if applicable): ☐

To be provided by the candidate
Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters
Special items: 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 total exam	Your mark
Section One: Multiple-choice	20	20	40	40	25	
Section Two: Short response	11	11	60	70	45	
Section Three: Extended answer	4	4	50	53	30	
				Total	100	

Instructions to candidates

1. The rules for the conduct of ATAR course examinations are detailed in the 2016 Year 11 Course Handbook. Sitting this examination implies that you agree to abide by these rules.

2. Answer the questions according to the following instructions.

   Section One: Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through the square, then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answer. 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. Wherever possible, confine your answers to the line spaces provided. Use a black or blue pen for this section. Only graphs and diagrams may be drawn in pencil.

3. When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to **three** significant figures and include appropriate units where applicable.

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

5. 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 questions that you are continuing to answer at the top of the page.

6. The Chemistry Data Sheet 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, do not erase or use correction fluid, and shade your new answer. 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

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1. Consider the ion below

$$^{191}_{76}X^{3+}$$

Which one of the following lists the number of protons, neutrons and electrons for this ion correctly?

	Protons	**neutrons**	**electrons**
(a)	191	115	73
(b)	115	76	79
(c)	73	115	76
(d)	76	115	73

2. The electronic structure of a neutral atom is 2, 8, 18, 8, 2.

If the nucleus has 11 more neutrons than protons what would be the mass number of the atom?

(a) 38

(b) 49

(c) 87

(d) 103

3. Covalent bonds are most commonly found between

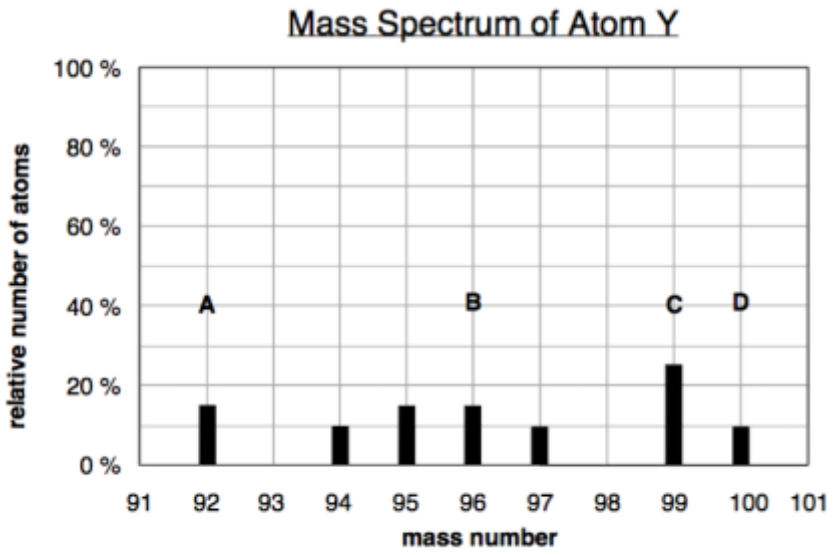
(a) Elements with similar but relatively high first ionisation energies

(b) Elements with low first ionisation energies

(c) Elements with significantly different first ionisation energies

(d) Gaseous and solid elements (room temperature)

Questions **4** and **5** relate to the mass spectrum of element Y below:



4. Based on the mass spectrum of atom Y, which of the following statements is false?

   (a) peak A and peak D come from atoms that have the same number of electrons

   (b) there are seven isotopes of atom Y

   (c) peak C comes from the most abundant isotope of atom Y

   (d) peak D comes from an atom with 4 more protons than the atom that gave peak B.

5. Which peak comes from an atom with the greatest number of neutrons?

   (a) A

   (b) C

   (c) D

   (d) all peaks in the spectrum have the same number of neutrons

6. Which of the the following is the best definition of a mole?

   (a) A mole of any substance has a atomic mass equal to that of carbon-12.

   (b) A mole of any substance contains the same number of particles as 12.0 g of naturally occuring carbon.

   (c) A mole of any substance contains 6.02×10^{23} particles of the substance.

   (d) A mole is equivalent to 12.0 g of atoms of any isotope.

See next page

7. Which one of the following compounds exhibit(s) geometrical isomerism?

I. $CH_3CH=CHCH_3$

II. $(CH_3)_2C=CH_2$

III. $(CH_3)_2C=C(CH_3)_2$

IV. $CH_3CH=C(CH_3)CH_2CH_3$

(a) I., II. and IV. only

(b) I. and III. only

(c) IV. only

(d) I. and IV. only

8. Which ionisation requires the most energy?

(a) $K(g) \rightarrow K^+(g) + e^-$

(b) $K^+(g) \rightarrow K^{2+}(g) + e^-$

(c) $Ca(g) \rightarrow Ca^+(g) + e^-$

(d) $Ca^+(g) \rightarrow Ca^{2+}(g) + e^-$

9. In which of the following pairs are both elements more electronegative than carbon?

(a) Be and Li

(b) F and Ne

(c) N and F

(d) Ge and Si

10. Which one of the following sets of substances have been correctly identified?

	Ionic	Covalent Molecular	Covalent Network	Metallic
(a)	NH_4NO_3	NO_2	SiO_2	Sn
(b)	NaCl	SiO_2	CO_2	Mg
(c)	SiC	CO_2	C	Hg
(d)	$Mg(OH)_2$	SO_3	C	Si

11. Bromine reacts with both ethane and ethene. A difference in the two reactions is

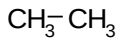
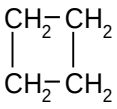
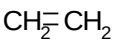
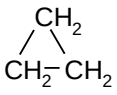
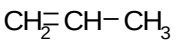
(a) Hydrogen gas is produced with ethane but not with ethene

(b) Reaction with ethane is much slower that with ethene.

(c) Reaction with ethene occurs only in sunlight

(d) Hydrogen bromide gas is produced with ethene but not with ethane

12. Which statement concerning hydrocarbons 1 – 6 shown below is incorrect?

1. 	2. 	3. 
4. 	5. 	6. 

(a) 4 and 6 are unsaturated and can undergo combustion reactions in limited oxygen.

(b) 6 is a structural isomer of 5

(c) 1 and 2 are aliphatic alkanes have the general formula C_nH_{2n+2}

(d) 1 and 2 are saturated and take part in addition reactions

13. Which one of the following contains ONLY pure substances which are elements?

(a) molten silver, oxygen gas, copper (II) chloride

(b) silver nitrate, sodium, helium gas, air

(c) hydrogen gas, bromine solution, argon, calcium

(d) iodine, mercury, manganese, sulphur

14. Which of the following changes would ***not*** cause an increase in the pressure of a gaseous system?

(a) The container is made larger

(b) Additional amounts of the same gas are added to the container

(c) The temperature is increased

(d) Another gas is added to the container.

See next page

Questions **15** and **16** relate to the information in the table below on the successive ionisation energies of 4 elements, labeled A, B, C and D.

Ionisation energy (MJ mol^{-1})

Element	1st	2nd	3rd	4th	5th	6th	7th	8th
A	1.09	2.35	4.62	6.22	37.83	47.28		
B	0.50	4.56	6.91	9.54	13.35	16.61	20.11	25.49
C	2.08	3.95	6.12	9.37	12.18	15.24	20.00	23.07
D	1.68	3.37	6.05	8.41	11.02	15.16	17.87	92.04

15. The pair of elements most likely to form a brittle crystal that conducts electricity when it is molten is?

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

16. The element that is the least reactive at room temperature is

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

17. Strontium arsenate has the formula $Sr(AsO_3)_2$ and lead(IV) tungstate dihydrate has the formula $Pb(WO_4)_2.2H_2O$

The correct formula for aluminium tungstate and lithium arsenate are:

(a) $Al_4(WO_4)_3$ $LiAsO_3$
(b) $Al_2(WO_4)_3$ Li_2AsO_3
(c) $Al_3(WO_4)_2$ $Li(AsO_3)_2$
(d) $Al_2(WO_4)_3$ $LiAsO_3$

18. For the hydrazine molecule with formula N_2H_4, (H_2NNH_2) which of the following correctly describes the electron arrangement?

	Number of NON-BONDING (lone) electron pairs	Number of BONDING electron pairs
(a)	1	3
(b)	2	5
(c)	4	10
(d)	4	5

19. How many unsaturated isomers, including geometric, are possible with the formula C_3H_5Cl ?

(a) 3

(b) 4

(c) 5

(d) 6

20. Which one of the following is true about elements in group 17?

(i) The first ionisation energy generally decreases with increasing atomic number

(ii) They all make a -1 ion.

(iii) Their chemical reactivity decreases descending the group

(iv) They are all diatomic elements that are solids at room temperature.

(v) Their electronegativity increases descending the group.

(a) (i), (ii), and (iii)

(b) (i), (ii), iii) and (iv)

(c) (ii), (iii) and (iv)

(d) All of them

End of Section One

See next page

Section Two: Short answer **45% (70 Marks)**

This section has eleven (11) questions. Answer all questions. Write your answers in the spaces provided.

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 21 **(7 marks)**

The table below shows the atomic structure of six particles, represented by the letters A-F. The letters are not the symbols of the elements.

Particle	Protons	Neutrons	Electrons
A	1	1	1
B	8	9	8
C	12	12	10
D	14	14	14
E	1	2	1
F	13	14	10

(a) Which particle has a mass number of 28? _____

(b) Which two particles are positive ions? _____ and _____

(c) Which particle is in period 2 in the periodic table? _____

(d) Which two particles are isotopes of the same element? _____ and _____

(e) Which particle has an atomic number of 13? _____

(f) Which particle is in group 2? _____

(g) Which particle has similar chemical properties to Ca? _____

Question 22 **(7 marks)**

Complete the table below by naming or writing the chemical formulae of each substance.

Name	Formula
Rubidium dichromate	
	$CoHPO_4$
Dichlorine heptaoxide	
	SiP_4
Ammonium oxalate	
	$Fe_2(SO_3)_3$
Barium ethanoate	

Question 23 **(2 marks)**

Explain which isomer, but-1-ene or but-2-ene can exhibit geometric (cis/trans) isomerism.

Question 24 **(6 marks)**

Pure substances can be separated from mixtures by using physical separation methods. Separation is possible due to substances having different properties. Complete the table below by naming the technique for each example and the property that allows this method to work.

Substance to be recovered from mixture	Separation technique	Property making it possible
Sand from water		
Water from a salt solution		
Chlorophyll from plant pigment		

See next page

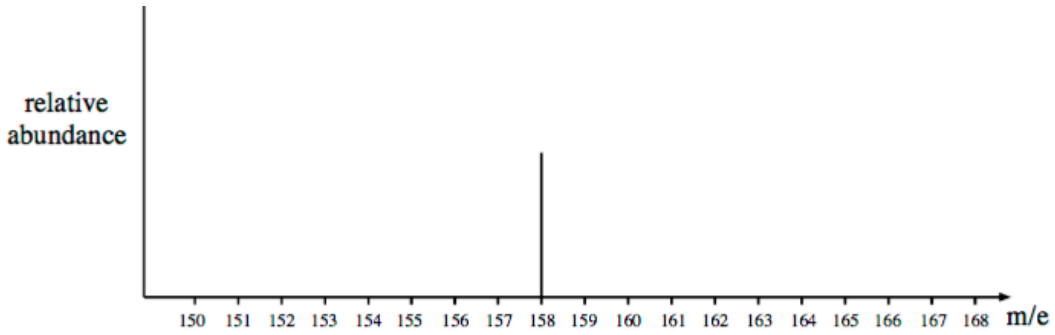
Question 25 **(12 marks)**

(a) State the meaning of the term isotope. (2 marks)

(b) Explain why isotopes have different physical properties but identical chemical properties. (2 marks)

Bromine that has been vaporised contains the isotopes ^{79}Br and ^{81}Br in almost equal proportions. Part of the mass spectrum of the molecular ions Br_2^+ is shown below.

(c) Complete the diagram to show the full spectrum of the molecular ions Br_2^+. (2 marks)



(d) Explain the number of peaks present in your diagram. (2 marks)

(e) Explain the ratio of the heights of the peaks in your diagram. (1 mark)

A sample of iron was analysed in a mass spectrometer. Four peaks with mass/charge (m/z) values were observed and are shown in the table below:

Relative abundance (%)	5.8	91.6	2.2	0.33
m/z	54	56	57	58

(f) Calculate the relative atomic mass of iron from this data. (2 marks)

(g) What is used to accelerate the ions in the mass spectrometer? (1 mark)

Question 26 **(5 marks)**

Superphosphate, $Ca(H_2PO_4)_2$ is the main source of phosphorus in agriculture.

(a) What is the % by mass of phosphorus in this superphosphate? (2 marks)

(b) What mass of hydrogen is present in 0.650 mol of $Ca(H_2PO_4)_2$? (2 marks)

(c) Hydrogen reacts with nitrogen to produce ammonia in an industrial process called the Haber process. The reaction is represented as follows:

$$3H_2(g) + N_2(g) \longrightarrow 2NH_3(g)$$

What volume of ammonia is produced from the reaction of 9.00 L of hydrogen with excess nitrogen if the gases are at the same temperature and pressure? (1 mark)

See next page

Question 27 **(8 marks)**

Draw the electron dot diagrams (Lewis structures) of the compounds below.

All valence shell electron pairs should be represented as : or —

N_2O(i.e. NNO)	Potassium sulfate
Magnesium phosphide	O_2

Question 28 **(8 marks)**

Explain each of the following:

(a) When most of the air is removed from inside a thin-walled metal can (by a vacuum pump), the can begins to crush (collapses inwards).

(2 marks)

(b) The strongest covalent bond of all is the triple bond in nitrogen N_2, hence its stability, yet liquid nitrogen boils at -196 C

(3 marks)

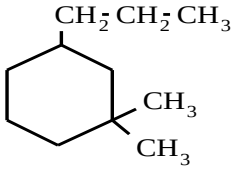
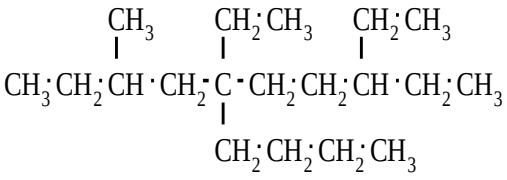
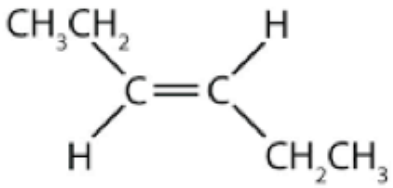
(c) Diamond is one of the hardest substances known; yet graphite, another allotrope of carbon, is soft and a good lubricating agent.

(3 marks)

See next page

Question 29 **(5 marks)**

Draw the structural formula or name the following compounds.

Name	Structural Formula
tetramethylbutane	
	
5,5-diethyl-3-methyloct-3-ene	
	
	

See next page

Question 30 **(8 marks)**

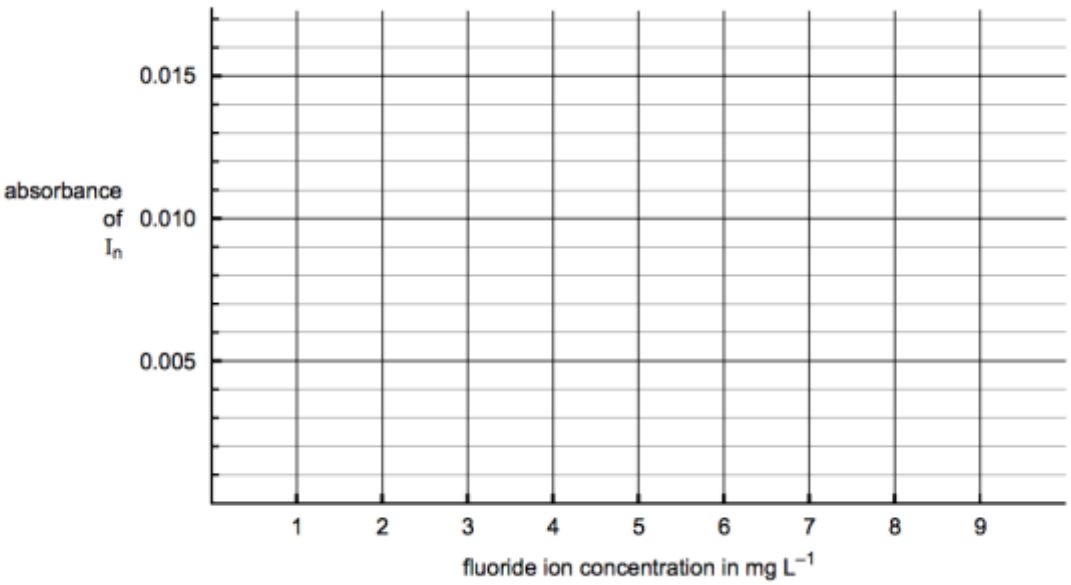
One method of determining the concentration of fluoride ions in tap water uses red- coloured indicator I_n. The indicator reacts with the fluoride ions in water to give a colourless product. The reaction can be represented as:

$$\underset{\text{red}}{I_n(aq)} + \underset{\text{colourless}}{F^-(aq)} \rightarrow \underset{\text{colourless}}{FI_n(aq)}$$

A calibration curve was prepared using different aqueous solutions of sodium fluoride, each of known fluoride ion concentration. A fixed concentration of the I_n indictor is then added to 25.00mL of each of the five sodium fluoride solutions and the water sample of unknown NaF concentration. The intensity of the red I_n colour of each mixture is the determined using the UV-visible spectrometer. The results are tabulated below:

Fluoride ion concentration in mg/L	**Absorbance of I_n**
1.00	0.0130
2.00	0.0110
3.00	0.0090
4.00	0.0070
5.00	0.0050
Water sample	0.0120

(a) Draw a calibration curve of the results in the grid below. (2 marks)



(b) Using your graph determine the concentration of the sodium fluoride and hence fluoride ion in the water sample. (1 mark)

(c) What is the mass (in grams) of fluoride ions present in a 250mL glass of tap water? (2 marks)

See next page

There are not sufficient amounts of sodium fluoride present in our tap water, so it is added to toothpastes as it helps to prevent cavities. Sodium fluoride can be manufactured by the reaction of sodium carbonate and hydrofluoric acid. The reaction is represented as follows:

$$2HF(aq) + Na_2CO_3(s) \Rightarrow 2NaF(aq) + CO_2(g) + H_2O(l)$$

(d) If 4.50kg of sodium carbonate is added to excess hydrofluoric acid, what mass of sodium fluoride can be recovered, once it is filtered, washed and dried? (3 marks)

Question 31 **(2 marks)**

Draw the structural formula of the organic product formed in each reaction described below:

Reaction	Organic product formed
Bromine solution is shaken with cyclohexane in UV light (1:1 ratio)	
Chlorine gas is bubbled through methyl propene	

End of Section Two

See next page

Section Three: Extended answer **30% (53 Marks)**

This section contains four (4) questions. You must answer all questions. Write your answers in the spaces provided.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression.

Final answers to calculations should be expressed 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: 50 minutes

Question 32 **(11 marks)**

Consider the following pure substances:

Mg **S_8** **$Mg_3(PO_4)_2$**

(a) Describe a physical test to distinguish between magnesium (Mg) and magnesium phosphate ($Mg_3(PO_4)_2$), other than physical appearance. (3 marks)

Pure substances	Physical test	Observation
Magnesium		Mg
Magnesium phosphate		$Mg_3(PO_4)_2$

See next page

(b) With reference to structure and bonding explain why magnesium phosphate is hard and brittle and sulfur is soft and powdery. (3 marks)

(c) Complete the table below by stating the particles present and describing the physical appearance of each substance at room temperature. (3 marks)

substance	particles present	describe the physical appearance
Mg		
S_8		
$Mg_3(PO_4)_2$		

(d) Magnesium phosphate can be produced by reacting phosphoric acid solution (H_3PO_4) with magnesium metal.Hydrogen gas is also produced. Write a balanced equation for this reaction. (2 marks)

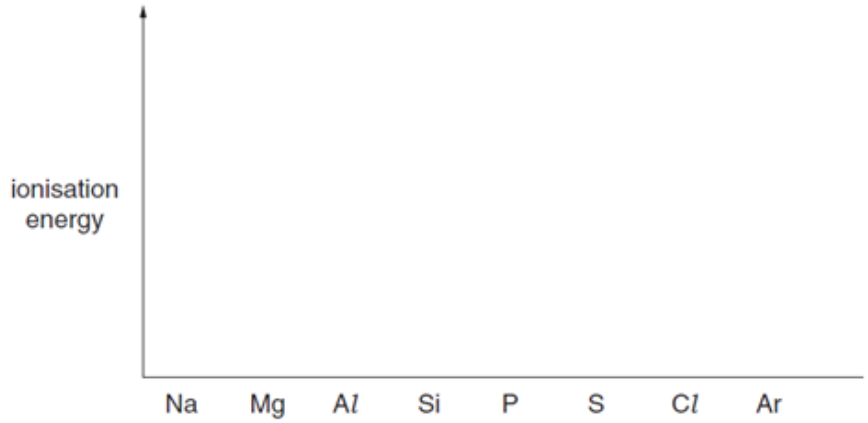
_____

See next page

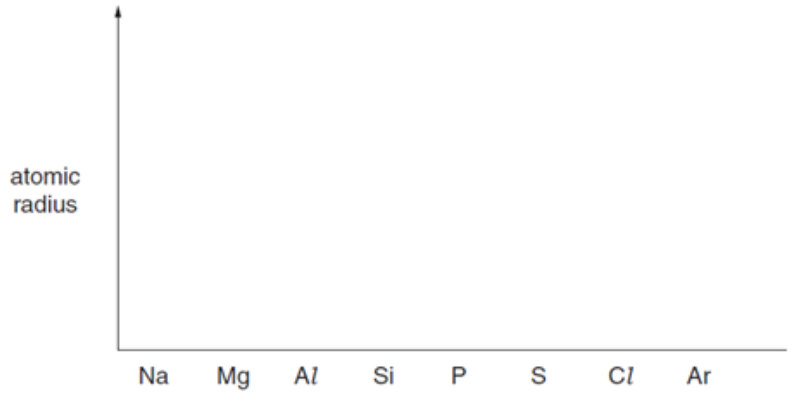
Question 33 **(14 marks)**

(a) Scientists often use sketch graphs to show trends. (2 marks)

(i) Draw a sketch graph to show the trend in **1st ionisation energy** across Period 3.



(ii) Draw a sketch graph to show the trend in **atomic radius** across Period 3.



(b) Explain the trend in atomic radius across Period 3 (2 marks)

_____

_____

_____

_____

(c) Periodic table trends assist us in making predictions about the physical and chemical properties of elements. List the elements given in order from lowest to highest in relation to:

(i) Melting point **Na, Al, K**

lowest _____highest (1 mark)

(ii) Chemical reactivity **At_2, F_2, Cl_2**

lowest _____highest (1 mark)

See next page

(d) Explain how the measurement of successive ionisation energies can assist in determining the electron configuration of an element. (2 marks)

(e) State and explain the trends in electronegativity across periods and down groups and discuss how the differences in electronegativity between reacting elements determines whether the substance formed is ionic or covalent. (6 marks)

Question 34 **(11 marks)**

Some rocks are found to contain silica (SiO_2) and calcium carbonate ($CaCO_3$). The percentage by mass of calcium carbonate in an 8.64 g sample of a particular rock was determined by crushing and mixing the sample with excess hydrochloric acid solution.

The equation for the reaction between calcium carbonate and hydrochloric acid is given below.

$$CaCO_3(s) + 2H^+(aq) \Rightarrow Ca^{2+}(aq) + H_2O(l) + CO_2(g)$$

The resulting solution was filtered and the residue (SiO_2) was washed and dried. The mass of SiO_2 recovered was 1.55 g.

(a) Using your knowledge of structure and bonding, suggest a reason why the silica does not react with hydrochloric acid solution. (1 mark)

(b) Why was **excess** hydrochloric acid added to the rock sample? (1 mark)

(c) Calculate the % by mass of calcium carbonate in the rock sample. (2 marks)

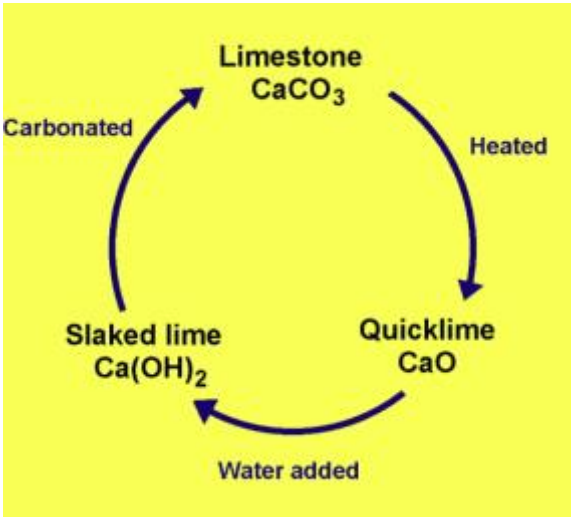
(d) The melting point of calcium carbonate is 825°C and of silica is 1600°C. With reference to structure and bonding explain the difference in the melting points of these two compounds. (3 marks)

See next page

Many of calcium carbonate's properties make it an extremely useful building material. It can be used in its natural form as limestone or marble.

It can be converted to calcium oxide (quicklime) or calcium hydroxide (slaked lime), as shown in the **Lime Cycle** at right.

Slaked lime (calcium hydroxide) can be used to manufacture mortar, plaster and cement.



(e) Mortar, plaster and cement are heterogeneous mixtures of slaked lime and sand and water. Explain the term "**heterogeneous**". (1 mark)

_____

_____

_____

(f) Use the diagram of the Lime cycle to write a balanced equation to show how calcium carbonate is converted into quicklime (CaO) when heated to 900°C. (1 mark)

Slaked lime, calcium hydroxide, is dissolved in water to produce lime water, a solution of calcium hydroxide, which is used to test for carbon dioxide gas. Calcium hydroxide is soluble in water whereas calcium carbonate is insoluble.

(g) What type of bond must be broken in order to dissolve both of these compounds? (1 mark)

_____

(h) What can you infer about the strength of these bonds in calcium carbonate compared to calcium hydroxide? (1 mark)

_____

See next page

Question 35 **(17 marks)**

(a) Why are hydrocarbons used extensively as fuels? (1 mark)

(b) When planning an MLC adventure camp, two students decided to research which fuel would be most energy efficient (produce the most energy per mL) as this would reduce the total volume they would need to carry. Their results are given in the table below.

Fuel	Molar mass	Enthalpy of combustion ΔH	density at 20°C	Energy released per 15.0 mL of fuel
Pentane	72.15 g/mol	3450 $kJmol^{-1}$	0.626 g/mL	449 kJ
Octane	114.2 g/mol	5460 $kJmol^{-1}$	0.692 g/mL	

Note: (i) **enthalpy of combustion (ΔH)** is the heat released in the burning of the fuel per mole of the compound

(ii) **density =** $\frac{\text{mass}}{\text{volume}}$

(c) One student, being an expert at chemical calculations quickly calculated that 15.0 mL of pentane could produce a maximum of 449 kJ of energy. However, another student needs your help to determine the maximum energy that could be released from 15.0 mL of octane.
Fill in the missing energy released for octane in the last column in the table and show your calculation below. (3 marks)

(d) Write a balanced equation for the burning of liquid octane in a plentiful supply of oxygen. (2 marks)

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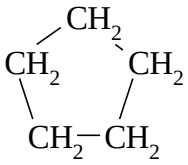
(e) In the reaction between octane and oxygen gas, 7.50L of liquid octane is reacted in excess air. What volume of carbon dioxide gas is produced at STP? (4 marks)

(f) Most reactions are not carried out at STP conditions but at higher temperatures, often at room temperature of approximately 25°C. If the combustion reaction was carried out at room temperature, how would this affect the volume of gas produced, assuming that the atmospheric pressure remains constant? Explain. (2 marks)

(g) Two isomers of C_6H_{12} have the following structures.

A



B

Both are colourless liquids. Describe a chemical test that could be used to distinguish between the two compounds. (3 marks)

Test	Observations
	isomer **A**
	Isomer **B**

(h) Give the equation, showing structural formula, for the distinguishing reaction described.
(2 marks)

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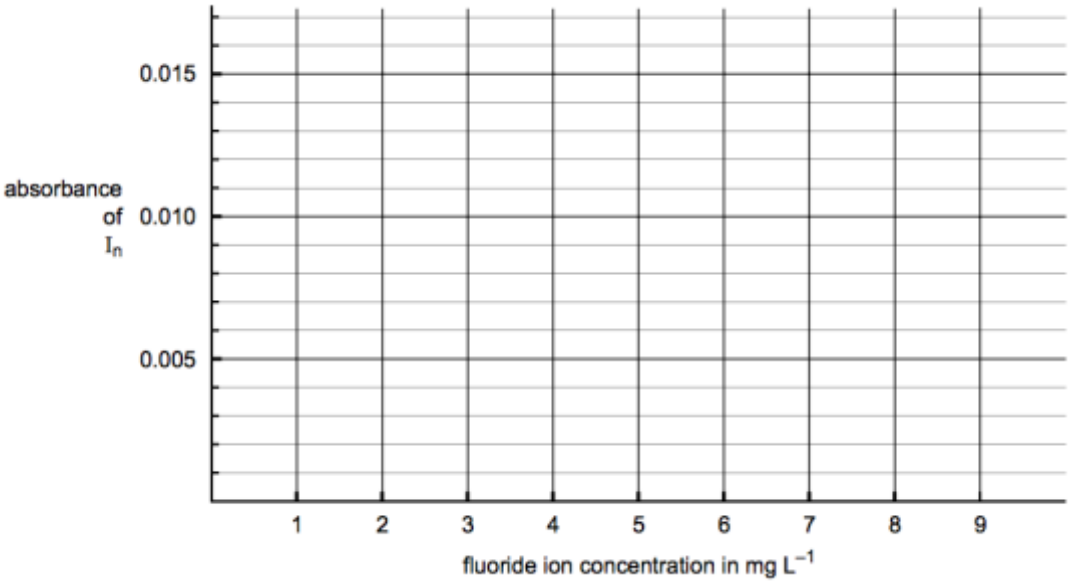

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