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CHEMISTRY

UNIT 1

2021

Name: _____

Teacher: _____

Time allowed for this paper

Reading time before commencing work: ten minutes
Working time: 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 calculators, which do not have the capacity to create or store programmes or text, are permitted in this ATAR course examination

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 material. 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 examination
Section One Multiple-choice	25	25	50	/ 25	/ 25
Section Two Short answer	11	11	60	/ 80	/ 35
Section Three Extended answer	5	5	70	/ 88	/ 40
					/ 100

Instructions to candidates

- Write your answers in this Question/Answer booklet preferably using a blue/black pen. Do not use erasable or gel pens.
- 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. Do not use erasable or gel pens. 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.

- When calculating numerical answers, show your working or reasoning clearly. Your working should be in sufficient detail to allow your answers to be checked readily and for marks to be awarded for reasoning. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.
- 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.
- Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.
- The Chemistry Data Book is not to be handed in with your Question/Answer booklet.

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

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

Suggested working time: 50 minutes.

1. Which of the following species contain 9 protons?

- (i) Fluorine-19
- (ii)
- (iii) Beryllium-9
- (iv)
- (v) F⁻

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

2. Isotopes of an element have the same

- (a) atomic number.
- (b) mass number.
- (c) number of neutrons.
- (d) physical properties.

3. Consider the information provided in the table below.

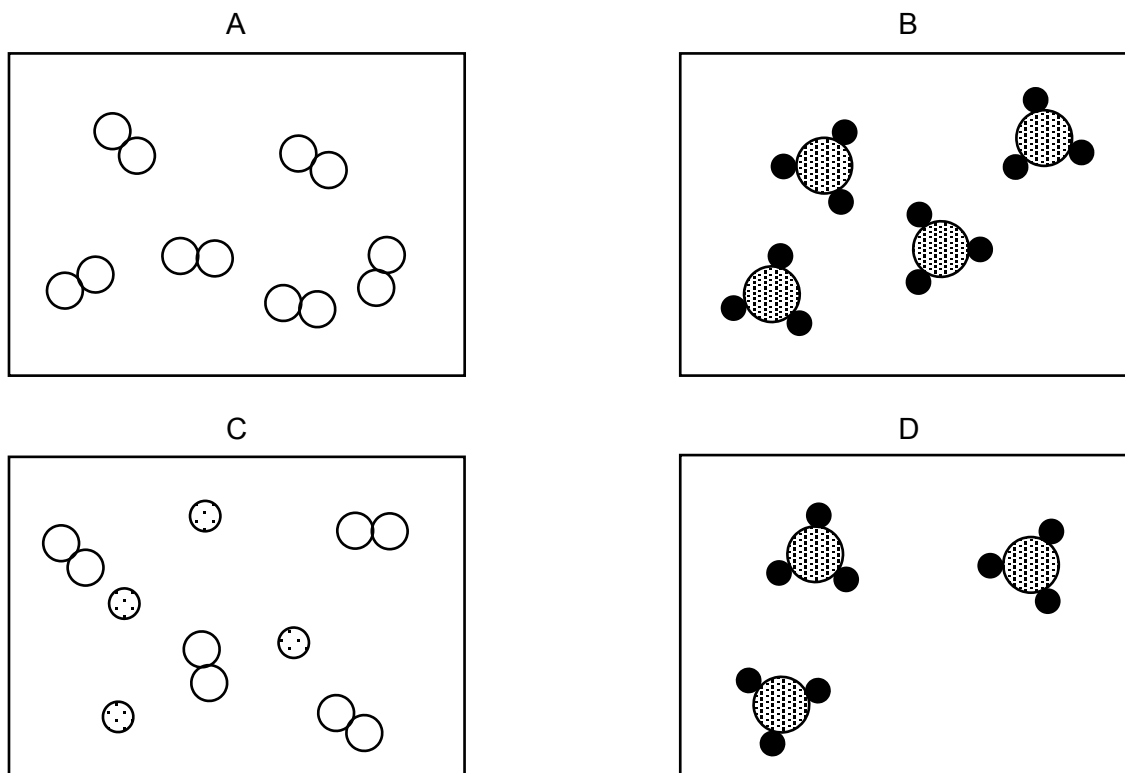
Substance	Melting point (°C)
Tin	232
Lead	327
Solder (tin + lead)	183-191

Which of the following statements provides the best justification for the melting point of solder?

- (a) The melting point of a mixture cannot be accurately determined.
- (b) The properties of a mixture depend upon its composition.
- (c) Solder is a covalent molecular substance.
- (d) A mixture will always have a lower melting point than its individual components.

Questions 4, 5 and 6 relate to the diagram below.

Four sealed canisters below (A, B, C and D) each contain different gas samples. The gases are represented by circles; each circle is an atom, and each pattern is a different type of atom.



4. The contents of which canister(s) would be described as a pure substance?

- (a) A only.
- (b) B only.
- (c) A and B only.
- (d) A and D only.

5. Which canister contains a noble gas?

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

6. How many of the canisters contain an element?

- (a) 1
- (b) 2
- (c) 3
- (d) 4

7. Which correctly lists the formulae for the stated ions?

	hydrogencarbonate	sulfide	dichromate
(a)	H_2CO_3^-	SO_4^{2-}	$\text{Cr}_2\text{O}_7^{2-}$
(b)	HCO_3^-	S^{2-}	Cr_2^{6+}
(c)	H_2CO_3	SO_3^{2-}	CrO_4^{2-}
(d)	HCO_3^-	S^{2-}	$\text{Cr}_2\text{O}_7^{2-}$

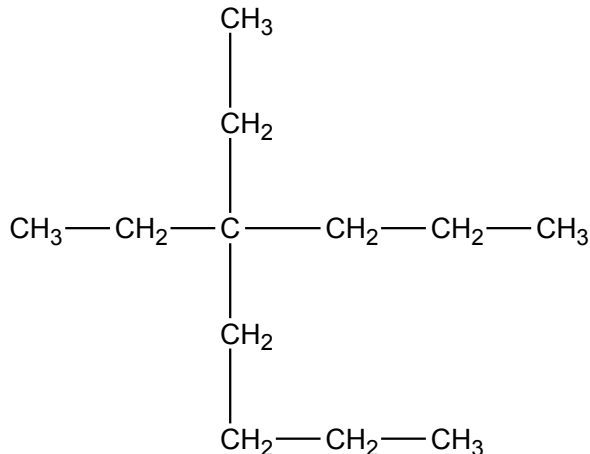
8. Which of the following is **not** common to both diamond and graphite?

- (a) Covalent network bonding.
- (b) High degree of hardness.
- (c) Insoluble in water.
- (d) Composed of carbon atoms.

9. Glow worms produce a blue-green light via a catalysed chemical reaction involving the chemical compound luciferin. Which statement regarding this reaction is correct?

- (a) This reaction is endothermic.
- (b) This reaction has a positive enthalpy change.
- (c) The system gains energy from the surroundings.
- (d) The reactants have greater enthalpy than the products.

10. Give the IUPAC name of the organic molecule below.



- (a) 3-butyl-3-propylpentane.
- (b) 3-ethyl-3-butylhexane.
- (c) 3-ethyl-3-propylheptane.
- (d) 4,4-diethyloctane.

11. One mole of ammonium carbonate formula units would contain

- (a) 6.022×10^{23} atoms of nitrogen.
- (b) 6.022×10^{23} atoms of hydrogen.
- (c) 6.022×10^{23} atoms of carbon.
- (d) 6.022×10^{23} atoms of oxygen.

12. When sugar ($C_{12}H_{22}O_{11}$) is gently heated in a saucepan, it eventually melts to form a thick liquid sugar syrup. When this syrup cools down, it forms hard sheets of toffee.

Classify the liquid sugar syrup according to the properties below.

	Type of bonding	Electrical conductor
(a)	covalent network	no
(b)	covalent molecular	no
(c)	covalent network	yes
(d)	covalent molecular	yes

13. The table below shows the typical colours produced by several elements when analysed in a flame test.

Element	Flame colour
Copper	green
Tin	blue-white
Boron	bright green
Antimony	pale green
Germanium	pale blue
Thallium	green
Indium	indigo

An unknown element was analysed and found to have the following characteristics;

1. It produced a green flame.
2. It is located in group 13.
3. It is classified as a metalloid.

Based on the information provided, the element is most likely to be

- (a) copper.
 (b) boron.
 (c) antimony.
 (d) thallium.
14. The properties of carbon nanotubes differ from the properties of bulk diamond and bulk graphite because
- (a) the covalent bonding in carbon nanotubes is much stronger.
 (b) the bonding in carbon nanotubes is regarded as covalent network.
 (c) the carbon nanotubes have a different chemical composition.
 (d) the surface area to volume ratio of carbon nanotubes is much greater.

Questions 15, 16 and 17 relate to the periodic table below.

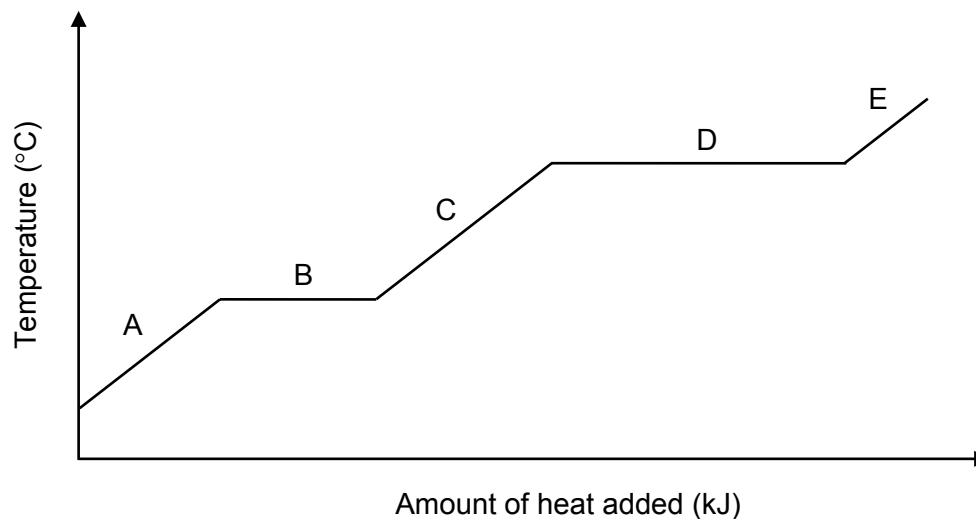
Consider the following partially drawn periodic table. Refer to the elements labelled A - I to answer the following questions.

A	B											C			D
						E					F		G		
	H												I		

15. Which pair of elements would have the same number of valence electrons?
- A and B
 - C and D
 - B and H
 - F and G
16. Which of the following elements would have the largest atomic radius?
- C
 - E
 - F
 - G
17. Which of the following elements would have the highest electronegativity?
- C
 - D
 - G
 - I
18. A sample of hex-2-ene was placed in a beaker containing excess water, as well as several millilitres of concentrated sulfuric acid. The reaction mixture was stirred and left until any reaction had stopped.
- Which of the following substances would **not** be found in the beaker at the completion of the reaction?
- $\text{CH}_3\text{CHCHCH}_2\text{CH}_2\text{CH}_3$
 - H_2O
 - H_2SO_4
 - $\text{CH}_3\text{CHOHCH}_2\text{CH}_2\text{CH}_2\text{CH}_3$

Questions 19 and 20 refer to the following graph.

Consider the following heating curve for substance X.



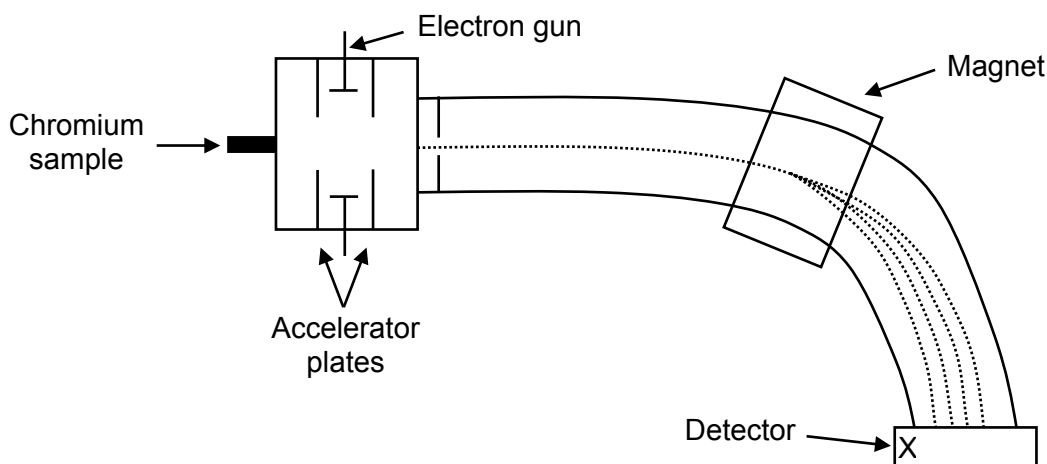
19. Substance X could be
- (a) salt water.
 - (b) ethanoic acid solution.
 - (c) pentane.
 - (d) skim milk.
20. The equation for the process occurring at B can be best represented by
- (a) $X(s) \rightarrow X(l)$ H is positive.
 - (b) $X(s) \rightarrow X(l)$ H is negative.
 - (c) $X(l) \rightarrow X(s)$ H is positive.
 - (d) $X(l) \rightarrow X(s)$ H is negative.
21. Which of the following ionic formulae is **not** written correctly?
- (a) Fe_2O_3
 - (b) $FeCl_2$
 - (c) Fe_2NO_3
 - (d) $FePO_4$
22. Copper saucepans conduct heat well because
- (a) they have a shiny lustrous appearance.
 - (b) they contain dissociated electrons.
 - (c) the metal atoms are free to move around.
 - (d) the delocalised electrons can move freely.

23. Which organic compound has a different molecular formula to the others?

- (a) 3-ethylpent-1-ene.
- (b) 4,4-dimethylhex-2-ene.
- (c) 3-ethyl-2-methylpent-2-ene.
- (d) 3-ethylhex-3-ene.

24. A sample of chromium was analysed by mass spectrometry, to determine its relative atomic mass (A_r). The chromium was determined to have four (4) naturally occurring isotopes; chromium-50, chromium-52, chromium-53 and chromium-54.

Consider the simplified diagram of the mass spectrometer below, showing the 4 paths travelled by the different isotopes.



Which isotope would have hit the detector closest to point X?

- (a) Chromium-50.
- (b) Chromium-52.
- (c) Chromium-53.
- (d) Chromium-54.

25. Which of the following correctly identifies one advantage and one disadvantage of biofuels when compared to fossil fuels?

	Advantage	Disadvantage
(a)	Made from renewable resources.	Increased contribution to the formation of acid rain.
(b)	Produces fewer $\text{CO}_2(\text{g})$ emissions.	Have a lower energy density.
(c)	Widely available in all countries.	Production generally requires a high water input.
(d)	Reduced destruction of ecosystems.	Lower cost of production.

End of Section One

Section Two: Short answer**35% (80 marks)**

This section has 11 questions. Answer **all** questions. Write your answers in the spaces provided.

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

Suggested working time: 60 minutes.

Question 26**(7 marks)**

The subatomic particle arrangement of an atomic species can be written in symbol form, using the notation shown in the following example;

+

- (a) Complete the table for the species above. (3 marks)

Number of protons	Number of neutrons	Electron configuration

- (b) Using the same notation as sodium above, write the symbol for an atomic species that matches each of the following descriptions. (4 marks)

Description	Symbol
An alkaline-earth metal in period 4.	
An anion with the same electron configuration as a neon atom.	
An element in group 15 which exists as a diatomic gas at room temperature.	
A potassium ion with 22 neutrons.	

Question 27**(5 marks)**

Over the centuries, many scientists have contributed to our understanding of the atom. Some of the most notable have been;

Dalton *Rutherford* *Thomson* *Bohr* *Chadwick*

Complete the table below, by writing the name of the scientist next to the description of their contribution to atomic theory.

Contribution to atomic theory	Scientist
Proposed that electrons move in circular orbits with particular energy levels.	
Discovered the neutron.	
Discovered the electron.	
Proposed that atoms of the same element are the same, and atoms of different elements are different.	
Proposed that an atom was largely empty space, with a central nucleus.	

Question 28**(4 marks)**

Complete the following table, by writing the name of the compound and classifying the compound according to its physical properties.

	Name of compound	Classification of physical properties (ionic or covalent)
H ₂ SO ₃		
ZnSO ₃		

Question 29**(11 marks)**

The use of nanoparticles in cosmetics has become widespread in recent years. One example is the addition of gold nanoparticles (nanogold) to face cream. Research has suggested that the nanogold provides antifungal, antibacterial and anti-inflammatory benefits, as well as improving the firmness of skin.

- (a) Define a nanoparticle. (1 mark)

- (b) Give one (1) reason consumers may be concerned about the use of nanoparticles in cosmetics such as face cream. (1 mark)

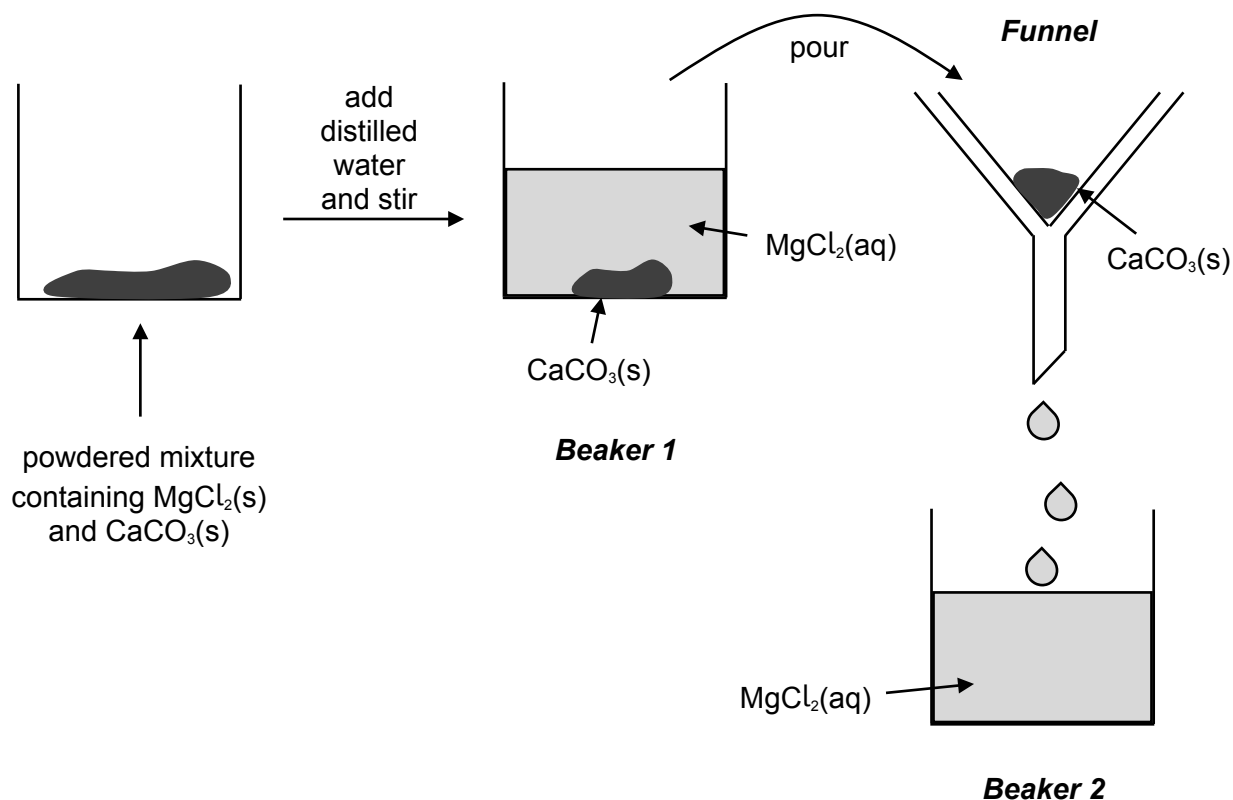
A sample of face cream was analysed by atomic absorption spectroscopy (AAS) to determine the concentration of nanogold present.

The face cream was dissolved and aspirated into a flame. A beam of light, at a wavelength matching that of gold, was then passed through the flame. This light was produced by a hollow cathode lamp containing gold atoms.

- (c) Explain, in terms of electron behaviour, how the gold atoms in the hollow cathode lamp can create an emission spectrum with these unique wavelengths. (5 marks)

Question 30**(8 marks)**

A beaker contained a powdered mixture of magnesium chloride and calcium carbonate. A chemistry student designed and carried out a procedure to separate the powders. A sketch of part of the method they followed is shown below.



- (a) Complete the following table, by stating which piece of equipment contains a substance matching the description given. (3 marks)

Description	Equipment (Beaker 1, Beaker 2, Funnel)
A pure substance	
A homogeneous mixture	
A heterogeneous mixture	

The filtrate in Beaker 2 was analysed and found to be a good conductor of electricity.

- (b) Explain why, using an appropriate chemical equation to support your answer. (4 marks)

- (c) Name the process that could be used to separate and retain both the components of Beaker 2. (1 mark)

Question 31**(5 marks)**

Consider the following statements.

1. Elements W, X, Y and Z are all in the same period.
2. W and X form an ionic compound with the formula WX_3 .
3. Y and X form an ionic compound with the formula YX_2 .
4. Y and Z form an ionic compound with the formula YZ.
5. At room temperature, X exists as a diatomic, gaseous halogen.

Use the information above to complete the table below.

	Circle the correct answer			
Element W is likely to be in group	2	3	13	15
The element with 6 valence electrons would be	W	X	Y	Z
The element with the largest atomic radius would be	W	X	Y	Z
When combined, W and Y are most likely to form	a covalent compound	an ionic compound	an alloy	
The compound X_2Z is most likely to contain	covalent bonding	ionic bonding	metallic bonding	

Question 32

(7 marks)

Amoxicillin and cefalexin are antibiotics that can be used to treat bacterial infections. Information regarding these two compounds is provided in the table below.

	Molecular formula	Molecular mass (g mol ⁻¹)
amoxicillin	C ₁₆ H ₁₉ N ₃ O ₅ S	365.402
cefalexin	C ₁₈ H ₁₇ N ₃ O ₄ S	371.406

- (a) Which antibiotic contains a higher percentage by mass of oxygen? Support your answer with appropriate calculations. (3 marks)

A sample of amoxicillin was taken for analysis. It was treated so that all the nitrogen was converted to nitrogen dioxide, NO₂(g). The mass of NO₂(g) was determined to be 0.364 g.

- (b) Calculate the initial mass of amoxicillin that had been analysed. (4 marks)

Question 33**(11 marks)**

Biodiesel is a biofuel which can be produced from various oils, such as those extracted from sunflower, cottonseed or soybean.

The combustion of a particular biodiesel ($C_{18}H_{32}O_2$) is represented in the chemical equation below.



- (a) Balance the equation above, by adding the correct coefficients. (1 mark)
- (b) Explain, with reference to the Law of Conservation of Mass, why chemical equations need to be balanced. (2 marks)

As shown in the chemical equation above, the combustion of biodiesel releases heat energy.

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

- (d) Calculate the mass of biodiesel that would need to be combusted to produce one megajoule (1 MJ) of energy in the chemical reaction above. (3 marks)

Note: 1 MJ = 10^3 kJ.

- (e) State two (2) reasons why it is not always possible to use biodiesel in place of regular diesel. (2 marks)

1.	
2.	

Question 34**(7 marks)**

When barium hydroxide solution is poured over powdered ammonium chloride, the white solid dissolves and a chemical reaction takes place. The reaction produces water, ammonia gas and a barium chloride solution. The enthalpy change for this reaction is known to be +13 kJ per mole of ammonium chloride.

- (a) Write a balanced molecular, thermochemical equation representing this reaction. (4 marks)

- (b) Explain, in terms of structure and bonding, why the ammonia produced in this reaction is a gas at room temperature. (3 marks)

Question 35

(7 marks)

Magnesium and phosphorus are both found in period 3.

- (a) Write the electron configuration of magnesium and phosphorus. (2 marks)

Mg	
P	

These elements have the ability to combine to form the ionic compound magnesium phosphide, Mg_3P_2 . This results in the formation of two new species.

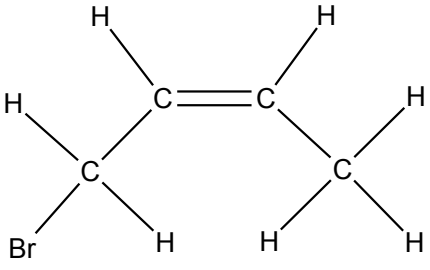
- (b) Write the electron configuration for the new species that form. (2 marks)

Mg^{2+}	
P^{3-}	

- (c) Explain why each of these changes in electron configuration occur when magnesium and phosphorus react. (3 marks)

Question 36**(8 marks)**

- (a) Complete the table below by writing the IUPAC name or drawing a structural diagram for each organic substance. (6 marks)

Structural diagram	IUPAC name
	
	1,2-dichloro-3-ethylpentane
	2-methylpropene

- (b) Write a chemical equation for the catalysed reaction that occurs between benzene and chlorine gas. Use structural formulae for all organic substances. (2 marks)

End of Section Two**SEE NEXT PAGE**

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Section Three: Extended answer**40% (88 marks)**

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

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

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

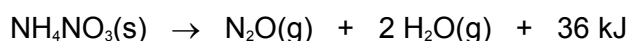
Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

Suggested working time: 70 minutes.

Question 37**(15 marks)**

Ammonium nitrate (NH_4NO_3) is a white, crystalline solid, often used in mining explosives. Unfortunately, this compound has also been the cause of several of the worst industrial accidents that have occurred over the past few decades.

At high temperatures, ammonium nitrate can decompose violently, producing a rapid release of gases that cause an explosion. This process can be represented by the following chemical equation;



- (a) Classify this reaction as an endothermic or exothermic reaction, and state whether the value of ΔH is positive or negative. (2 marks)

	Circle the correct answer	
The reaction is	endothermic	exothermic
The value of ΔH is	positive	negative

- (b) Compare the energy associated with the bond breaking and bond making processes involved in this reaction. (2 marks)

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Question 38**(18 marks)**

A group of chemistry students were investigating the trends in first ionisation energy of various elements. The students made the following hypothesis;

“The first ionisation energy of an element will increase with increasing atomic number.”

In order to investigate further, the students researched online to find the relevant data, which they summarised in the table below.

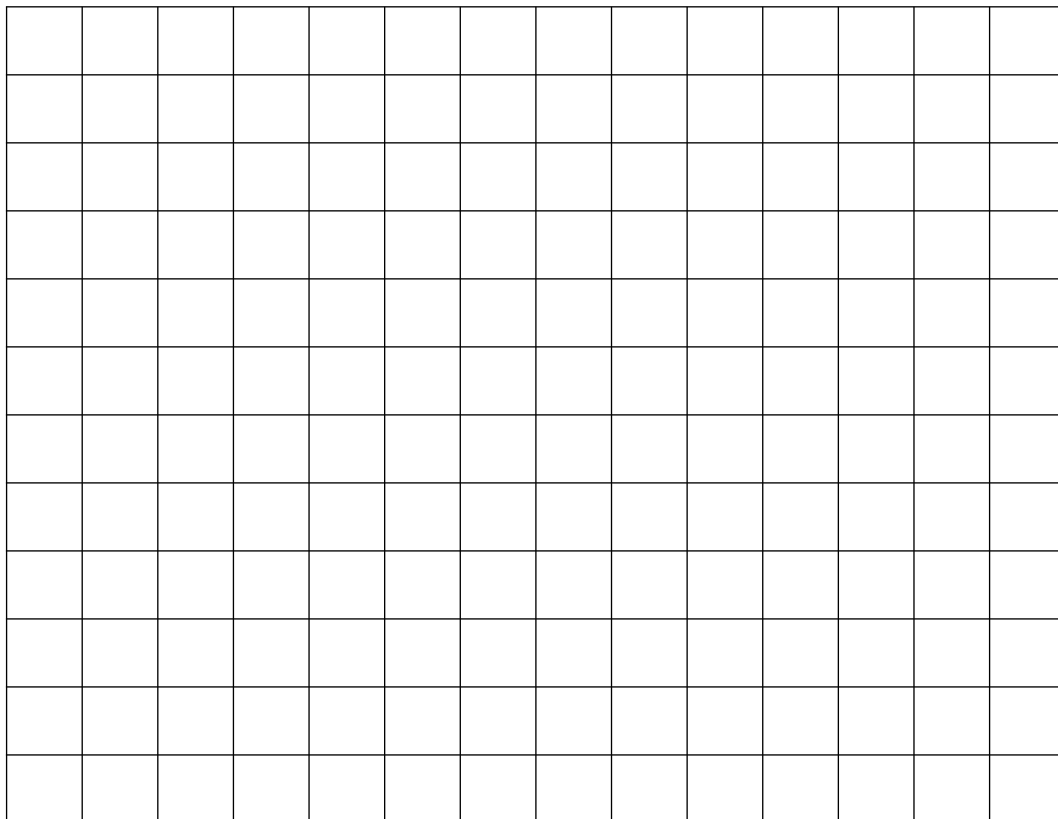
Element	O	F	Ne	Na	Mg	Al	Si	P
Atomic number	8	9	10	11	12	13	14	15
First ionisation energy (kJ mol ⁻¹)	1314	1681	2081	496	738	578	787	1012

- (a) Define ‘first ionisation energy’. (2 marks)

- (b) State whether the data obtained by the students would be classified as ‘primary’ or ‘secondary’ data. Justify your answer. (2 marks)

(c) Graph the data collected by the students, using the grid below.

(4 marks)



(d) Explain the increasing trend in first ionisation energy for the elements with atomic number 13-15. (3 marks)

- (e) Explain why there is such a large difference in the first ionisation energy of neon and sodium. (2 marks)

- (f) Suggest an appropriate range, in which the first ionisation energy of the element with atomic number 16 would fall. Justify your answer. (3 marks)

- (g) Which of the elements studied by the students would have (2 marks)

(i) the highest electronegativity?

(ii) the smallest atomic radius?

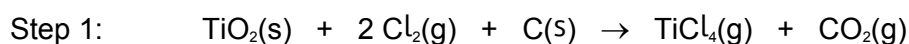
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Question 39**(19 marks)**

Titanium is a valuable metal due to its high strength, low density, resistance to corrosion and stability at high temperatures. However, titanium is expensive because of the difficulty in purifying it from its ore.

Most titanium is found in 'rutile', which is an ore containing high levels of the compound titanium dioxide, $\text{TiO}_2(\text{s})$. Australia currently produces about 55% of the world's rutile. This ore can be treated in order to produce pure titanium metal, as described in the following process.

The first step involves reacting the rutile ore with chlorine gas and excess coke (carbon). This reaction is carried out at a temperature of $800\text{ }^\circ\text{C}$. At the completion of this step, a mixture of TiCl_4 and CO_2 gases is produced, as shown in the chemical equation below.



In the second step, the TiCl_4 gas is reduced by reaction with molten magnesium metal.



The table below provides information regarding some of the compounds involved in these processes.

	Melting point ($^\circ\text{C}$)	Boiling point ($^\circ\text{C}$)
TiCl_4	-24.1	136.4
CO_2	-	-78.5
Mg	650	1091
Ti	1668	3287
MgCl_2	714	1412

A 2420 kg batch of rutile ore, containing 61.7% TiO_2 (by mass), was processed as described in Step 1.

- (a) Calculate the mass of chlorine gas that would be required to completely react with the rutile ore. (5 marks)

The products of Step 1 – a mixture of TiCl_4 and CO_2 gases – were then collected. This gas mixture was gradually cooled, resulting in the separation and isolation of 2695 kg of TiCl_4 .

- (b) Use the information provided in the table, to explain how the cooling process would allow separation of TiCl_4 to occur. (2 marks)

The isolated TiCl_4 was then reacted with excess hot, molten magnesium, to produce solid titanium and molten magnesium chloride, as shown in Step 2.

- (c) Use the information provided in the table, to suggest a temperature at which this reaction might be carried out. Justify your answer. (3 marks)

The titanium produced was to be used in the manufacture of corrosion-resistant piping. Each metre length of pipe contained 5.43 kg of titanium.

- (d) Calculate the length of piping that could be manufactured from 2695 kg of TiCl_4 . (5 marks)

- (e) State the property of metals which allows them to be shaped easily into pipes. Explain the basis of this property, in terms of structure and bonding. (4 marks)

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Question 40**(18 marks)**

A group of students were investigating the effect of 'degree of saturation' on the reactivity of organic compounds. In order to do this, they obtained samples of the four (4) organic compounds shown in the table below.

Structural diagram	IUPAC Name
	octane
	oct-1-ene
	octa-1,3-diene
	octa-1,3,5-triene

- (a) Describe the difference between a 'saturated' and an 'unsaturated' organic compound, and provide an example of each from the table above. (3 marks)

The students began the investigation by measuring a 10.0 g sample of each organic liquid into four separate test tubes. To each test tube they added 0.50 g of liquid bromine. The test tubes were immediately stoppered, and the contents were gently and continuously swirled.

The time taken for the red colour of the bromine liquid to fade to colourless was measured. The students recorded their results in the table below.

Compound	Time taken for red to fade to colourless (seconds)			Average
	Trial 1	Trial 2	Trial 3	
octane	red colour was not observed to fade			–
oct-1-ene	6.07	5.98	6.13	
octa-1,3-diene	2.94	3.07	3.11	
octa-1,3,5-triene	2.06	2.01	2.04	

(b) Complete the table above by calculating the average time taken for the remaining three test tubes. (3 marks)

(c) Give two (2) reasons the students performed multiple trials. (2 marks)

(d) Complete the table below, by listing the variables for this investigation. (3 marks)

Independent variable	
Dependent variable	
One (1) controlled variable	

For this experiment, it was important that the moles of organic liquid be present **in excess**, ensuring the liquid bromine would be entirely consumed by any reaction that occurs.

- (e) Why is it important for the organic liquid to be present in excess? (1 mark)

- (f) Name the type of reaction that would have taken place in the test tube containing oct-1-ene. Write a chemical equation for this reaction, using structural formulae. (3 marks)

Name of reaction type	
Chemical equation	

Whilst no reaction was observed in the test tube containing octane, these substances **can** react when exposed to appropriate conditions.

- (g) State the conditions that would be required for a reaction to take place, and name the type of reaction that would occur under these circumstances. (2 marks)

Conditions required	
Name of reaction type	

- (h) Write a conclusion that the students could draw from the data collected in this investigation. Your conclusion should relate to your stated variables. (1 mark)

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Question 41**(18 marks)**

Paleoclimatology is the study of Earth's past climates, throughout different geologic ages. As there was no direct data collected and recorded for these periods of time, scientists obtain information from things such as rocks, sediments, ice sheets, fossils, shells and tree rings.

The element oxygen is one of the most important factors when studying past climates. Oxygen has two (2) isotopes, oxygen-16 and oxygen-18. These are often referred to as 'light' oxygen and 'heavy' oxygen respectively.

- (a) Define an isotope. (1 mark)

- (b) Complete the table below for both isotopes of oxygen. (2 marks)

	Number of protons	Number of neutrons	Electron configuration
^{16}O			
^{18}O			

- (c) Compare and contrast the physical and chemical properties of isotopes. (2 marks)

Many compounds, such as water (H_2O), incorporate the element oxygen. Water molecules will therefore contain either an atom of 'light' or an atom of 'heavy' oxygen. As the Earth's climate changes, the ratio of these two isotopes of oxygen present in water also changes.

Two key process in the water cycle are evaporation and condensation. The identity of the oxygen isotope present in the water molecule will slightly alter the rate at which the water will undergo condensation and evaporation.

Due to the differing rates of condensation and evaporation, scientists have discovered that ocean water contains significantly higher levels of oxygen-18, when compared to snow found at the North and South poles, which in turn contains significantly higher levels of oxygen-16.

- (d) Calculate the relative molecular mass for a single molecule of water containing each oxygen isotope. Predict which type of water will undergo the processes of condensation and evaporation more readily. (4 marks)

	Relative molecular mass (M_r)	Which process will occur more readily? ('condensation' or 'evaporation')
Water containing 'light' oxygen		
Water containing 'heavy' oxygen		

Fossils of plants, animals and corals often contain calcium carbonate (CaCO_3) and silicon dioxide (SiO_2). Both of these compounds also incorporate oxygen, and therefore by analysing the ratio of 'light' to 'heavy' oxygen in these fossils, scientists are able to determine information about past climates.

It has been demonstrated that fossils containing higher levels of 'light' oxygen correspond to periods of global warming. Contrarily, fossils containing higher levels of 'heavy' oxygen corresponds to cold climates, such as the ice ages.

Samples of calcium carbonate from different fossilised species were analysed, and mass spectroscopy was used to determine the isotopic composition of the oxygen present in the CaCO_3 . The results of this analysis are shown in the table below.

Sample	Percent abundance (%)	
	^{16}O	^{18}O
Fossil A	99.79	0.21
Fossil B	99.68	0.32

- (e) State which fossil (A or B) is more likely to have come from an organism that lived during an ice age. Calculate the average relative atomic mass of the oxygen found in this 'ice age fossil'. (3 marks)

Calcium carbonate (CaCO_3) and silicon dioxide (SiO_2) are both compounds found in fossils, that can be analysed for their oxygen content. They are both hard and brittle substances, yet the bonding in each is different.

- (f) State the predominant type of bonding present in both CaCO_3 and SiO_2 , and briefly describe the structure of each. (4 marks)

- (g) Other than hardness and brittleness, state one other physical property that CaCO_3 and SiO_2 have in common, and one that distinguishes them. (2 marks)

Common property	
Distinguishing property	

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Question 38 (c)

