Name:_____________________________

Pre-Y12 Chemistry A-Level summer home learning

In September 2020, you will begin your studies of the A-level Chemistry course. In order to help you prepare, you must spend a total of 3 hours on this home learning project over the summer.

This will be due to your Y12 form tutor on your first day.

Part 1: 1.5 hours done? □

Read the extracts and complete the following task.

From the list below, choose the topic that you found most interesting:

1. Chemistry of the Solar System
2. Biochemistry
3. Thermodynamics
4. Chirality

Explain why you found this topic most interesting and include in your response one interesting fact about the topic that you have researched yourself.

Your response should be at least half a side of A4. You may type and print your response.

Part 2: 1.5 hours done? □

Answer all the exam questions. These are from the GCSE course and all supporting knowledge should be secure before arriving in September. You should thoroughly complete any revision necessary to answer the questions. You will be given the answers during your first week.

Part 1

Article 1: Taken from "Mars vs. Titan: A Showdown of Human Habitability" by Kasha Patel

As far as we know, Earth is the only planet with life. It has accessible liquid water, food, and WiFi. But what if there is another place in the universe where humans could survive and comfortably watch Netflix? Scientists are searching for other habitable locations across the universe and are looking at two possible candidates: Mars and Saturn's moon Titan. Studying these and other celestial bodies can help scientists learn about chemical processes that occur in our solar system and help us understand our own planet's past, present, and future.

When thinking about living on another planet, we must first think about the conditions on Earth that help us survive. On Earth, humans can walk around on the surface, breathe oxygen, drink liquid water, survive at a comfortable temperature, and live with protection from the sun's energetic waves. Finding all of those conditions on a different stellar object is not easy. So scientists are looking for the next best thing, with Titan and Mars in the running.

Titan's gassy air

Titan is perhaps an unexpected candidate for human habitation because it is not even a planet, although it has many planet-like features. It is the second largest moon in our solar system, larger than our moon and the planet Mercury. More importantly, **Titan is the only moon in our solar system to have an atmosphere and clouds—traits that make it similar to Earth.**

Titan's air is about 95% nitrogen (N_2) and 5% methane (CH_4)—coincidentally a minor ingredient in farts though not the odorous kind. It also has trace amounts of other carbon-rich compounds. The quantity of methane in Titan's air is one of the biggest chemical differences from our home planet. Instead of water, Titan's clouds, rain, and lakes are composed of liquid methane and ethane (C_2H_6).

Methane plays an important part in maintaining Titan's thick atmosphere. It contributes to the greenhouse gas effect, which helps keep the moon's temperatures from dropping very low. Without methane, temperatures would be low enough for nitrogen gas to condense into liquid, and the atmosphere would collapse. Here on Earth, water vapor and carbon dioxide are the predominant greenhouse gases.

TITAN'S COMPLEX CHEMISTRY—During its 13-year tour of Saturn and its moons, NASA's Cassini spacecraft revealed that the chemistry of Titan's atmosphere is more complex than scientists previously thought. Nitrogen and methane in the upper atmosphere are exposed to sunlight and energetic particles. This exposure drives the formation of more complicated compounds, which could then combine into molecules with atomic masses of up to 8,000 daltons.

Titan's atmospheric methane also drives the formation of more complex organic compounds. Atmospheric methane and nitrogen molecules are exposed to the sun's ultraviolet light and high-energy particles that accelerate in Saturn's magnetic field. This energy drives reactions with nitrogen, hydrogen, and carbon to create more complex organic compounds.

Some of those complex organic compounds are aromatic molecules, such as benzene. Others are negatively charged compounds known as **carbon-chain anions (for example, CN^- and C_2H^-). These linear compounds are thought to be the building blocks for more complex molecules and may be the basis for the earliest forms of life, including life on Earth.** Scientists are not sure how or why, but these complex molecules drift lower in the atmosphere, are transformed into a complex haze of organic aerosols, and eventually reach Titan's surface.

Life on Titan?

As it is, Titan is completely unsuitable for terrestrial life. The extremely cold temperatures of −180 °C (approximately −290 °F) would freeze any water present, and all Earth life is based on water. And while the atmospheric pressure on Titan is moderate—1.5 times the pressure of Earth's atmosphere, about what divers experience 15 feet underwater—there is no oxygen in it. So humans would have to live in an enclosed environment that could be warmed up and filled with oxygen, perhaps produced from the frozen water that is present on Titan.

If we could manage to pull off this technological feat, would we be sharing the planet with native life forms unlike life on Earth? Scientists have speculated that perhaps life could exist that is based not on liquid water, but on liquid hydrocarbons such as methane or ethane, which are abundant on Titan. As a source of energy, such life might use the reaction of acetylene and hydrogen, two gases that are known to exist on Titan, since their combination gives off lots of energy:

$C_2H_2 + 2\ H_2$ fi C_2H_6 $\Delta H^\circ = -311$ kJ/mol

No one has yet seen any compelling evidence for life on Titan, and it's hard to imagine how life would overcome the problems of operating at such low temperatures (where chemical reactions get very slow). But it would sure be cool to visit Titan to check out the possibilities!

Unfortunately, getting to Titan is tough. Unmanned satellites have taken years to reach the distant moon, and currently we do not have the technology to transport humans that far. But scientists have been exploring another possibility for our future home, and this one is much closer.

MARTIAN CARBON—Carbon dioxide (CO_2) forms in Mars' mantle. The gas enters the atmosphere directly through volcanoes, or is crystallized from magmas, and later released into the air. The gas can interact with polar caps. When ultraviolet light from the sun strikes a CO_2 molecule, it splits into carbon monoxide (CO) and oxygen. The CO can then break down into carbon and oxygen. Scientists have proposed that some carbon atoms would have enough energy to escape Mars' atmosphere. This loss mechanism is called ultraviolet photodissociation. While this process releases oxygen into the atmosphere, Mars only contains a trace amount of oxygen, not enough for breathing, according to Renyu Hu, a planetary scientist at NASA's Jet Propulsion Laboratory.

Mars: Dusty and rusty

Mars is at a viable distance for human space travel—it would take about seven months to get there—but its living conditions are not ideal. The planet is blasted by harmful ultraviolet radiation. It has a weak magnetosphere that would not provide much protection from space radiation or the sun's incoming charged particles. There is not enough oxygen for us to breathe. The Martian surface mainly features iron dust and rocks that give the planet its red, rusty color. Mars could be nicknamed "Dusty Rusty."

So why are scientists studying ol' Dusty Rusty? Geologic evidence on Mars suggests that the planet was once like Earth with lakes, warm weather, and possibly life. Scientists are exploring whether life could survive on present-day Mars.

One obstacle for human habitation on present-day Mars is its atmosphere. The atmosphere, primarily composed of carbon dioxide, is currently about 100 times thinner than Earth's. The thin atmosphere makes it impossible for humans to breathe and stay warm.

How to get energy on Mars: Use iron, man

Just like on Earth and Titan, living organisms on Mars would need energy to survive. Mars has a few potential energy sources that could help microorganisms grow. The National Aeronautics and Space Administration's (NASA) Mars rover, named Curiosity, even detected organic molecules in a rock-powder sample. But Mars does not have abundant organic material on its surface like Titan.

What it does have is a lot of iron. On Earth, microbes use energy from chemical reactions with iron in rocks—and the same could be true for Mars. Microorganisms could absorb energy from an iron reduction-oxidation reaction. The Martian environment has many electron donors and acceptors, such as iron (Fe^{2+}, Fe^{3+}), hydrogen (H_2), perchlorate (ClO_4^-), and carbon monoxide (CO).

Although scientists have not yet found life on Mars, NASA is looking to send humans to Mars in the 2030s. SpaceX plans to accomplish this by 2024.

What it does have is a lot of iron. On Earth, microbes use energy from chemical reactions with iron in rocks—and the same could be true for Mars. Microorganisms could absorb energy from an iron reduction-oxidation reaction. The Martian environment has many electron donors and acceptors, such as iron (Fe^{2+}, Fe^{3+}), hydrogen (H_2), perchlorate (ClO_4^-), and carbon monoxide (CO).

Although scientists have not yet found life on Mars, NASA is looking to send humans to Mars in the 2030s. SpaceX plans to accomplish this by 2024.

Survivor: Mars

Researchers have already developed a lot of the technology needed to sustain life on Mars. Spacesuits could help us withstand the low pressure, and dome bubbles could shield inhabitants from the sun's harmful radiation and provide a breathable atmosphere. NASA is also investigating how oxygen can be obtained from the carbon-dioxide atmosphere and how to extract water from rocks. (Note: Researchers this summer reported evidence that liquid water likely exists on Mars.) Researchers have simulated Martian soil here on Earth and were able to grow simple foods, such as tomatoes and peas.

Even though Mars might be more amenable to human habitability than Titan, researchers continue to study the distant moon as they suspect the universe contains many similar celestial bodies. Thousands of other planets have been discovered in the past two decades, and many of them have conditions similar to those found on Titan. So figuring out how to potentially survive there could apply to other planets in the galaxy.

If nothing else, Titan and Mars provide insight on Earth's past and future. Think of Earth, Titan, and Mars as a movie trilogy that tells the story of the evolution of life. Titan is the prequel showing Earth before life. Earth shows the present environment with life. Mars is the sequel to Earth, showing a post-terrestrial world. By exploring these places (and others), scientists are learning more about how life on Earth was created and what could be in store for our future.

Article 2: An extract taken from "The Science of Everyday Life" by Marty Jopson

Sweet, juicy strawberries, cake still warm from the oven and, my favourite, honey straight from the comb… Most of us enjoy eating sweet things, to the extent that seeking them out seems to be hard-wired into our brains. Yet our ability to taste sweetness is remarkably non-specific, and is fooled by a host of chemicals that seem to bear little resemblance to sugar. Not only that, but when it comes to sweetness, ordinary sugar, or sucrose, isn't very sweet at all.

The sweetest chemical so far discovered goes by the name of lugduname and ranks about 250,000 times sweeter than sucrose. What's perplexing for chemists, though, is that lugduname doesn't bear any structural resemblance to other sugars. This poses a little bit of a problem for science, as the usual way that a chemical receptor works is that it recognizes just a small portion of a molecule, maybe the arrangement of a half-dozen atoms or so. It doesn't matter what shape the rest of the molecule is, as long as those half-dozen atoms are in the right places. It's called the lock and key model, and so long as a chemical has the key, it will fit the lock. Sucrose and lugduname don't appear to share any such kind of key.

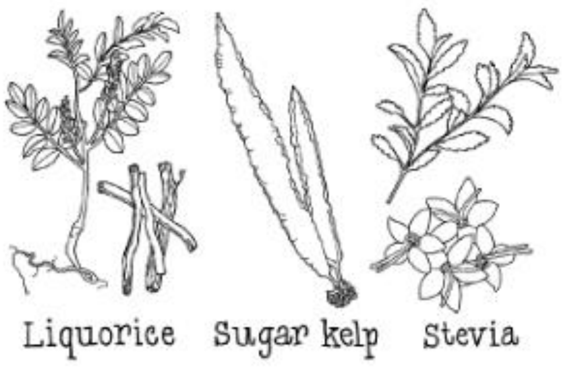
The term sugar itself denotes a group of chemicals of different lengths of chains of carbon atoms, including an oxygen, and often bent into a ring. The simplest sugars contain just one of these rings, and include glucose and fructose. Two simple sugars can hook together to make compounds such as sucrose, which is really a fructose stuck together with a glucose. All of these chemicals share common structures, and it is easy to imagine how it is that they register as sweet, as they all possess the right key.

Things start to get a bit weirder when you look at sugar substitutes. We are all familiar with sweeteners, such as aspartame, found in a whole host of food products including diet fizzy drinks. Many people presume that sugar substitutes are entirely synthetic and made in a lab. It turns out that nature was there long before the diet industry, and you can find sugar substitutes in surprising places.

My own personal favourite, because it surprised me when I first encountered it on an ecology field trip, can be found at the seaside. Next time you walk along a rocky shore line keep your eyes peeled for fronds of *Saccharina latissima*, or sugar kelp as it is commonly known. It's fairly distinctive and easy to spot once you know what to look for. It's a type of brown seaweed that comes in single, undivided blades, and is often a couple of metres (around 6 ft) long and about 10 to 15 cm (4–6 inches) wide. What makes it particularly distinctive is that the edge of the blade is flat or gently wavy, while the centre is all puckered up. If you allow a length of sugar kelp to dry out, a white powder forms on the surface, which is deliciously sweet with a hint of the sea. Although, if you are going to start licking bits of seaweed, I suggest you consult a proper identification guide first. While sugar kelp is popular in places such as Japan, other nations are not so keen.

Instead you could turn to glycyrrhizin, found in the woody roots of *Glycyrrhiza glabra*, more commonly called the liquorice plant, and used in the production of liquorice sweets. While glycyrrhizin is only fifty times sweeter than sucrose, it does seem to linger on your taste buds, giving liquorice one of its unique characteristics. It is also best eaten in moderation, as not only can it cause a rise in blood pressure, but it also has laxative effects.

Finally, my last example of an artificial sweetener from a natural source is stevia, or more precisely the steviol glycoside group of chemicals derived from the South American sugarleaf herb. These chemicals are about 150 times sweeter than sucrose, temperature stable, acid-resistant and non-fermentable



by yeasts. All of which has made them very popular as food additives, to the extent that both the The Coca-Cola Company and PepsiCo have produced stevia-based sweeteners.

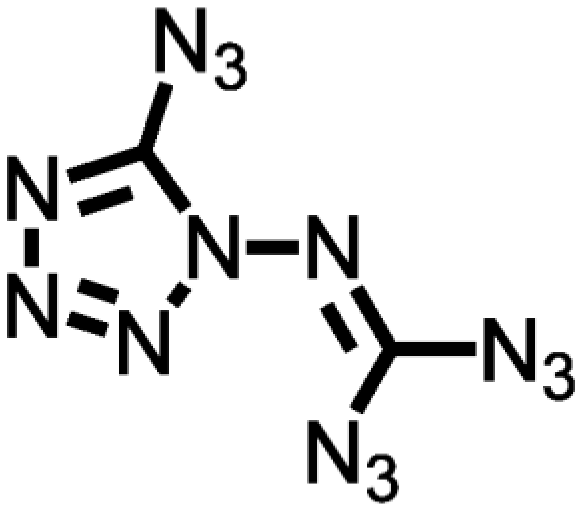
What these sugar-free sugar substitutes have in common is that they all bear some structural resemblance to sucrose itself. It therefore comes as no surprise that our taste buds detect them as sweet, as they all possess the key to the sweetness lock. So how, then, does the super-sweet lugduname work? There are a number of theories about our ability to detect sweetness, and the most recent is called the multi-point attachment theory, developed by biologists at the University of Lyon in France. In this theory, the sweetness receptor on the tongue detects not one big structural region but up to eight, smaller and spaced-apart areas – it looks like a molecule doesn't need to contain all eight regions to register as sweet. It's not so much a lock and key model as a sack full of locks and a key ring crammed with tiny keys. This also gives us an elegant way to envisage why super-sweet lugduname doesn't look like sucrose. While the molecules are dissimilar, they must each open enough of the eight locks to qualify as sweet. It may be that the sub-set of locks on the sweetness receptor they each open is different, but our tongue is clearly a lot less discriminating than we would imagine, and all sugar is not equal.

Article 2: An extract taken from Derek Lowe's blod "In the Pipeline"

When we last checked in with the Klapötke lab at Munich, it was to highlight their accomplishments in the field of nitrotetrazole oxides. Never forget, the biggest accomplishment in such work is not blowing out the lab windows. We're talking high-nitrogen compounds here (a specialty of Klapötke's group), and the question is not whether such things are going to be explosive hazards. (That's been settled by their empirical formulas, which generally look like typographical errors). The question is whether you're going to be able to get a long enough look at the material before it realizes its dream of turning into an expanding cloud of hot nitrogen gas.

It's time for another dispatch from the land of spiderweb-cracked blast shields and "Oh well, I never liked that fume hood, anyway". Today we have a fine compound from this line of work, part of a series derived from N-amino azidotetrazole. The reasonable response to that statement is "Now hold it right there", because most chemists will take one look at that name and start making get-it-away-from-me gestures. I'm one of them. To me, that structure is a flashing red warning sign on a dead-end road, but then, I suffer from a lack of vision in these matters.

But remember, N-amino azidotetrazole (I can't even type that name without wincing) is the *starting material* for the work I'm talking about today. It's a base camp, familiar territory, merely a jumping-off point in the quest for still more energetic compounds. The most alarming of them has two carbons, *fourteen* nitrogens, and no hydrogens at all, a formula that even Klapötke himself, who clearly has refined sensibilities when it comes to hellishly unstable chemicals, calls "exciting". Trust me, you don't want to be around when someone who works with azidotetrazoles comes across something "exciting".



It's a beast, all right. The compound is wildly, ridiculously endothermic, with a heat of formation of 357 kcal/mole, all of which energy is ready to come right back out at the first provocation (see below). To add to the fun, the X-ray crystal structure shows some rather strange bond distances, which indicate that there's a lot of charge separation – the azides are somewhat positive, and the tetrazole ring somewhat negative, which is a further sign that the whole thing is trembling on the verge of not existing at all.

And if you are minded to make some yourself, then *you* are on the verge of not existing at all, either. Both the initial communication and the follow-up publication go out of their way to emphasize that the compound just cannot be handled:

Due to their behavior during the process of synthesis, it was obvious that the sensitivities (of these compounds) will be not less than extreme. . .
The sensitivity of C2N14 is beyond our capabilities of measurement. The smallest possible loadings in shock and friction tests led to explosive decomposition. . .

Yep, below the detection limits of a lab that specializes in the nastiest, most energetic stuff they can think up. When you read through both papers, you find that the group was lucky to get whatever data they could – the X-ray crystal structure, for example, must have come as a huge relief, because it meant that they didn't have to ever see a crystal again. The compound exploded in solution, it exploded on any attempts to touch or move the solid, and (most interestingly) *it exploded when they were trying to get an infrared spectrum of it*. The papers mention several detonations inside the Raman spectrometer as soon as the laser source was turned on, which must have helped the time pass more quickly. This shows a really commendable level of persistence, when you think about it – I don't know about you, but one exploding spectrometer is generally enough to make recognize a motion to adjourn for the day. But these folks are a different breed. They ended up having to use a much weaker light source, and consequently got a rather ugly Raman spectrum even after a lot of scanning, but if you think you can get better data, then step right up.

No, only tiny amounts of this stuff have ever been made, or ever will be. If this is its last appearance in the chemical literature, I won't be surprised. There are no conceivable uses for it – well, other than blowing up Raman spectrometers, which is a small market – and the number of research groups who would even contemplate a resynthesis can probably be counted on one well-armored hand.

Task: Writing a Response

Explain why you found this topic most interesting and include in your response one interesting fact about the topic that you have researched yourself.

Your response should take about 15 minutes to research and 15 minutes to write. You should spend about 5 minutes checking your work.

You could start your research with the following links to additional resources.

- Chemistry of the Solar System: https://www.geochemsoc.org/publications/geochemicalnews/gn142jan10/atmosphericchemistryoftheg https://www.cheminst.ca/magazine/article/chemistry-on-mars/
- Biochemistry: https://www.sciencedaily.com/news/matter_energy/biochemistry https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1119266/
- Thermodynamics: https://www.nationalgeographic.org/topics/resource-library-thermodynamics/?q=&page=1&per_page=25 https://www.encyclopedia.com/science/encyclopedias-almanacs-transcripts-and-maps/safe-enough-kill-advances-chemistry-explosives

Your essay question should take at least half a side of A4 or you may type and print your response (around 250 words). You should write using accurate English.

Part 2

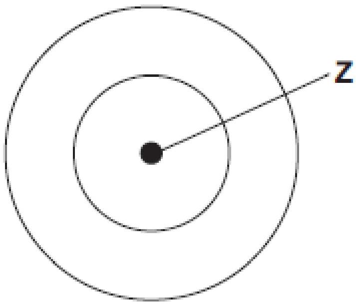
Answer all the exam questions. These are from the GCSE course and all supporting knowledge should be secure before arriving in September. You should thoroughly complete any revision necessary to answer the questions. You will be given the answers during your first week.

Q1.

There are eight elements in the second row (lithium to neon) of the periodic table.

(a) **Figure 1** shows an atom with two energy levels (shells).

Figure 1



(i) Complete **Figure 1** to show the electronic structure of a boron atom.

(1)

(ii) What does the central part labelled **Z** represent in **Figure 1**?

____

(1)

(iii) Name the sub-atomic particles in part **Z** of a boron atom.

Give the relative charges of these sub-atomic particles.

____

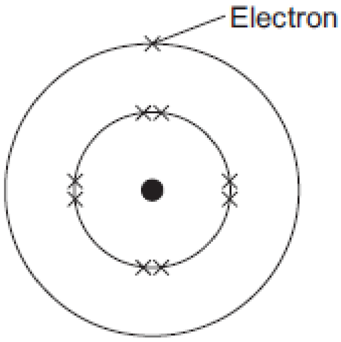
____

____

(3)

(b) The electronic structure of a neon atom shown in **Figure 2** is **not** correct.

Figure 2



Explain what is wrong with the electronic structure shown in **Figure 2**.

(3)
(Total 8 marks)

Q2.

This question is about atoms, molecules and nanoparticles.

(a) Different atoms have different numbers of sub-atomic particles.

(i) An oxygen atom can be represented as $^{16}_{8}O$

Explain why the mass number of this atom is 16.

You should refer to the numbers of sub-atomic particles in the nucleus of the atom.

(2)

(ii) Explain why $^{12}_{6}C$ and $^{14}_{6}C$ are isotopes of carbon.

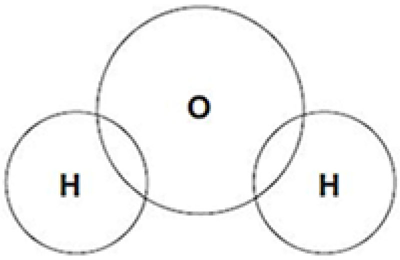
You should refer to the numbers of sub-atomic particles in the nucleus of each isotope.

(3)

(b) Hydrogen atoms and oxygen atoms chemically combine to produce water molecules.

(i) Complete the figure below to show the arrangement of the outer shell electrons of the hydrogen and oxygen atoms in a molecule of water.

Use dots (•) or crosses (×) to represent the electrons.



(2)

(ii) Name the type of bonding in a molecule of water.

(1)

(iii) Why does pure water **not** conduct electricity?

(1)

(c) Nanoparticles of cobalt oxide can be used as catalysts in the production of hydrogen from water.

(i) How does the size of a nanoparticle compare with the size of an atom?

(1)

(ii) Suggest **one** reason why 1 g of cobalt oxide nanoparticles is a better catalyst than 1g of cobalt oxide powder.

(1)

(Total 11 marks)

Q3.

This question is about elements and the periodic table.

(a) Newlands and Mendeleev both produced early versions of the periodic table.

(i) Complete the sentence.

In their periodic tables, Newlands and Mendeleev arranged the elements in

order of ____________________________ .

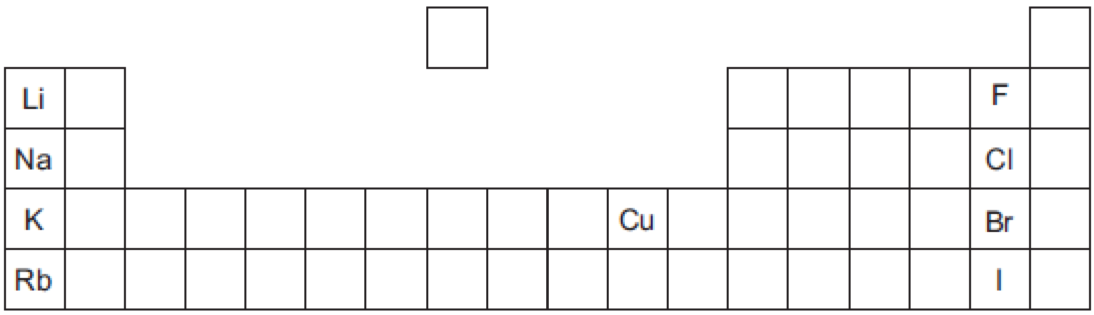
(1)

(ii) Name the particle that allowed the elements to be arranged in order of their atomic number in the modern periodic table.

____

(1)

(b) The diagram below shows the position of nine elements in the modern periodic table.



(i) Which **one** of the nine elements shown in the diagram above has the lowest boiling point?

____

(1)

(ii) Copper and potassium have different melting points and boiling points.
Give **one other** difference between the properties of copper and potassium.

____

____

(1)

(iii) Explain why the reactivity of the elements increases going down Group 1 from lithium to rubidium but decreases going down Group 7 from fluorine to iodine.

____

____

____

____

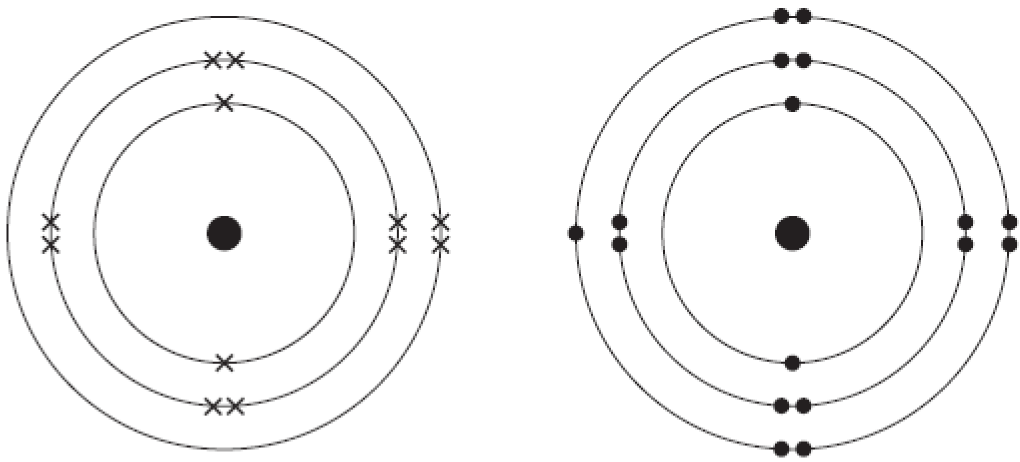
____

____

(4)
(Total 8 marks)

Q4.

(a) The diagram shows an atom of magnesium and an atom of chlorine.



Magnesium **Chlorine**

Describe, in terms of electrons, how magnesium atoms and chlorine atoms change into ions to produce magnesium chloride ($MgCl_2$).

(4)

(b) Calculate the relative formula mass (M_r) of magnesium chloride ($MgCl_2$).

Relative atomic masses (A_r): magnesium = 24; chlorine = 35.5

Relative formula mass (M_r) = __________

(2)

(Total 6 marks)

Q5.

A student investigated the law of conservation of mass.

The law of conservation of mass states that the mass of the products is equal to the mass of the reactants.

This is the method used.

1. Pour lead nitrate solution into a beaker labelled **A**.
2. Pour potassium chromate solution into a beaker labelled **B**.
3. Measure the mass of both beakers and contents.
4. Pour the solution from beaker **B** into beaker **A**.
5. Measure the mass of both beakers and contents again.

When lead nitrate solution and potassium chromate solution are mixed, a reaction takes place.

This is the equation for the reaction:

$$Pb(NO_3)_2(aq) + K_2CrO_4(aq) \longrightarrow PbCrO_4(s) + 2KNO_3(aq)$$

(a) What would the student see when the reaction takes place?

(1)

(b) The table shows the student's results.

	Mass in g
Beaker **A** and contents before mixing	128.71
Beaker **B** and contents before mixing	128.97
Beaker **A** and contents after mixing	154.10
Beaker **B** after mixing	103.58

Show that the law of conservation of mass is true.

Use the data from the table above.

(2)

(c) What is the resolution of the balance used to obtain the results in the table?

Tick (✓) **one** box.

0.01 g ☐ 0.1 g ☐ 1 g ☐ 100 g ☐

(1)

(d) Calculate the relative formula mass (M_r) of lead nitrate $Pb(NO_3)_2$

Relative atomic masses (A_r): N = 14 O = 16 Pb = 207

Relative formula mass = ____________________

(2)

(e) The formula of potassium chromate is K_2CrO_4

The charge on the potassium ion is +1

What is the formula of the chromate ion?

Tick (✓) **one** box.

CrO_4^{+} ☐

CrO_4^{2+} ☐

CrO_4^{-} ☐

CrO_4^{2-} ☐

(1)

(f) Another student also tests the law of conservation of mass using the same method.

The student uses a different reaction.

This is the equation for the reaction.

$$Na_2CO_3(aq) + 2HCI(aq) \longrightarrow 2NaCl(aq) + CO_2(g) + H_2O(I)$$

Explain why this student's results would **not** appear to support the law of conservation of mass.

(3)
(Total 10 marks)

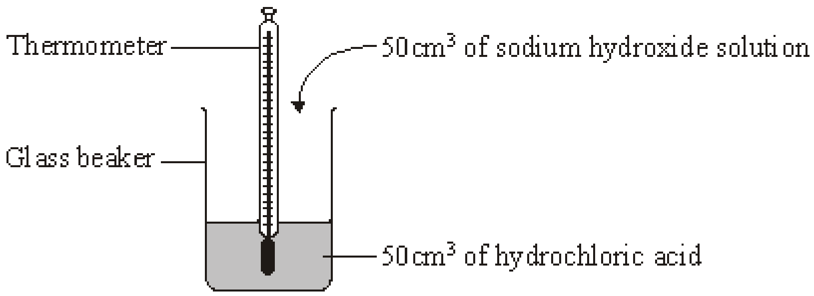
Q6.

Read the information about energy changes and then answer the questions.

A student did an experiment to find the energy change when hydrochloric acid reacts with sodium hydroxide. The equation which represents the reaction is:

$HCl + NaOH \rightarrow NaCl + H_2O$

The student used the apparatus shown in the diagram.



The student placed 50 cm^3 of hydrochloric acid in a glass beaker and measured the temperature.

The student then quickly added 50 cm^3 of sodium hydroxide solution and stirred the mixture with the thermometer. The highest temperature was recorded.

The student repeated the experiment, and calculated the temperature change each time.

	Experiment 1	Experiment 2	Experiment 3	Experiment 4
Initial temperature in °C	19.0	22.0	19.2	19.0
Highest temperature in °C	26.2	29.0	26.0	23.5
Temperature change in °C	7.2	7.0	6.8	4.5

(a) The biggest error in this experiment is heat loss.

Suggest how the apparatus could be modified to reduce heat loss.

(1)

(b) Suggest why it is important to stir the chemicals thoroughly.

____

(1)

(c) Which **one** of these experiments was probably carried out on a different day to the others?

Explain your answer.

____

____

(1)

(d) Suggest why experiment 4 should **not** be used to calculate the average temperature change.

____

____

(1)

(e) Calculate the average temperature change from the first three experiments.

____

Answer = ________________ °C

(1)

(f) Use the following equation to calculate the energy change for this reaction.

energy change in joules = 100 × 4.2 × average temperature change

____

Answer = ________________ J

(1)

(g) Which **one** of these energy level diagrams, **A** or **B**, represents the energy change for this reaction?

Explain why.

Diagram A

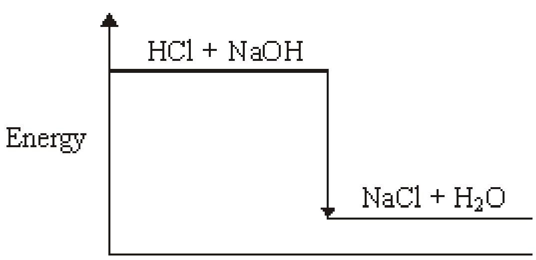
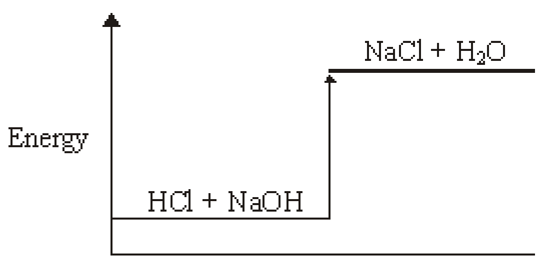


Diagram B



____

____

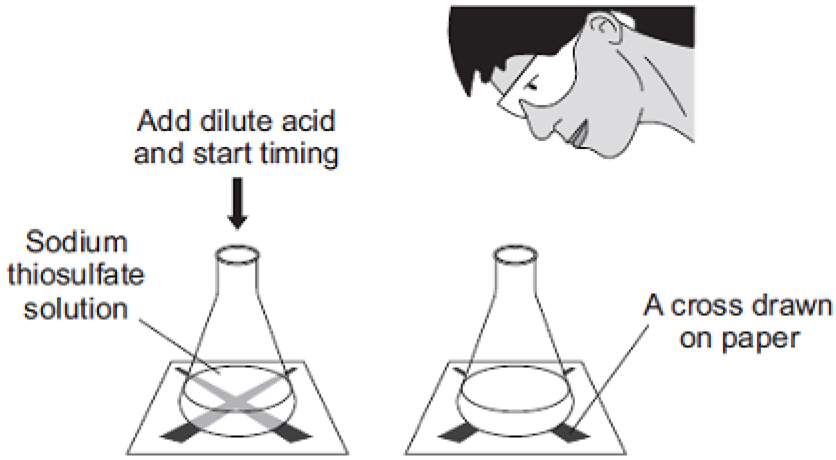
(1)

(Total 7 marks)

Q7.

Sodium thiosulfate solution reacts with hydrochloric acid. As the reaction takes place the solution slowly turns cloudy.

The diagram shows a method of measuring the rate of this reaction.



A student used this method to study how changing the concentration of the sodium thiosulfate solution alters the rate of this reaction.

The student used different concentrations of sodium thiosulfate solution. All the other variables were kept the same.

The results of the experiments are shown on the graph below.

(a) (i) Draw a line of best fit on the graph.

(1)

(ii) Suggest **two** reasons why all of the points do not lie on the line of best fit.

____

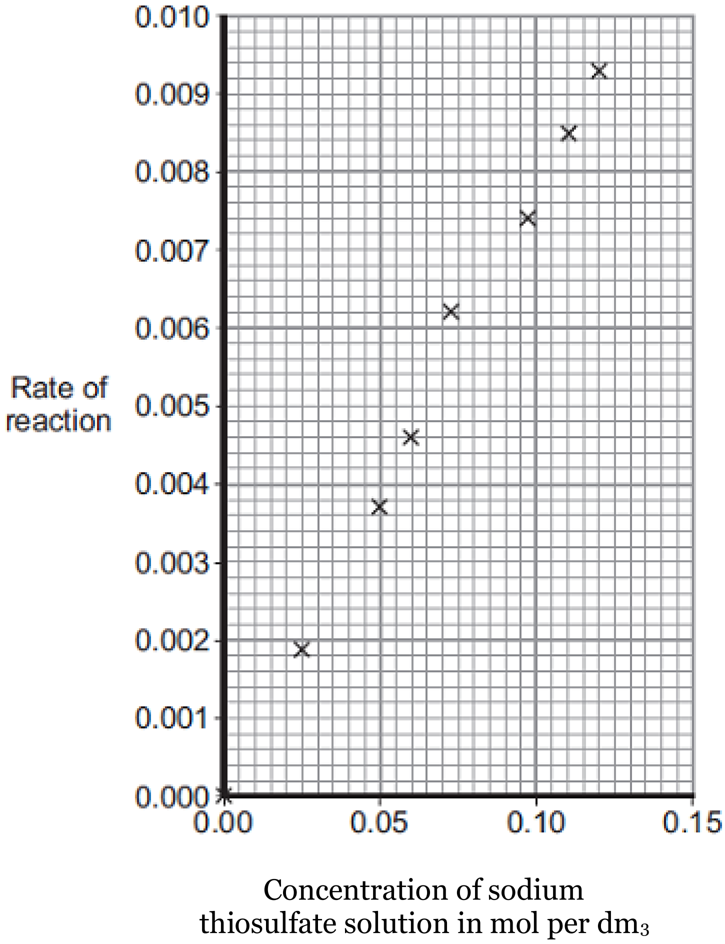
____

____

____

____

(2)



(b) (i) In a conclusion to the experiment the student stated that:

'The rate of this reaction is directly proportional to the concentration of the sodium thiosulfate.'

How does the graph support this conclusion?

____

____

(1)

(ii) Explain, in terms of particles, why the rate of reaction increases when the concentration of sodium thiosulfate is increased.

____

____

____

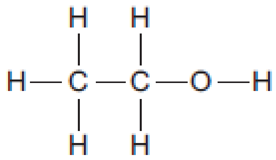
____

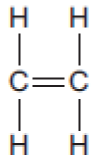
(2)
(Total 6 marks)

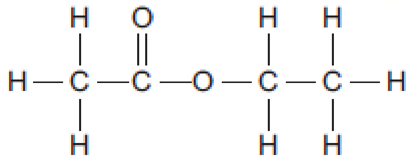
Q8.

The figure below shows the displayed structures of five organic compounds, **A, B, C, D** and **E**.

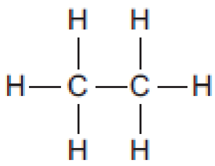
A **B** **C**

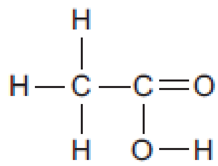






D **E**





(a) Choose which organic compound, **A, B, C, D** or **E**, matches the descriptions.

You may choose each compound once, more than once or not at all.

Write the letter of the compound that:

(i) is a saturated hydrocarbon ☐ **(1)**

(ii) comes from a homologous series with the general formula C_nH_{2n} ☐ **(1)**

(iii) has the empirical formula C_2H_6O ☐ **(1)**

(iv) reacts with calcium carbonate to produce carbon dioxide ☐ **(1)**

(v) reacts with compound **A** to produce compound **C**. ☐ **(1)**

(b) Compound **B** (C_2H_4) and C_8H_{18} are produced by cracking $C_{14}H_{30}$

$$C_{14}H_{30} \longrightarrow 3C_2H_4 + C_8H_{18}$$

(i) Give **two** conditions for cracking.

____

____

(2)

(ii) Explain why C_8H_{18} has a lower boiling point than $C_{14}H_{30}$

____

____

(2)

(c) Compound **B** is a colourless gas.

Give a chemical test and its result to show that compound **B** is unsaturated.

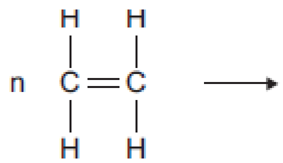
Test

Result

(2)

(d) Compound **B** is ethene.

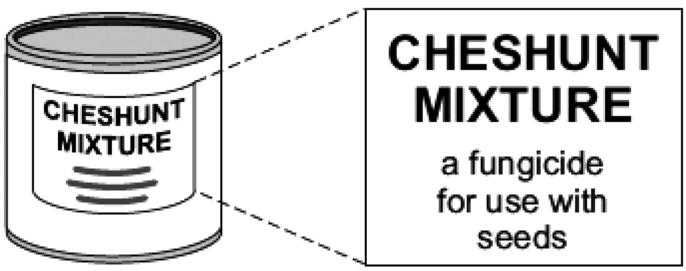
Complete the equation to show the formation of poly(ethene) from ethene.



(3)
(Total 14 marks)

Q9.

Cheshunt mixture is a powder containing copper sulfate, $CuSO_4$, and ammonium carbonate, $(NH_4)_2CO_3$



(a) A student tested the Cheshunt mixture.

(i) Hydrochloric acid was added.
A gas was produced that turned limewater milky.

Complete the sentence.

The gas was ________________________________ which shows

that ________________________ ions are in the mixture.

(2)

(ii) Sodium hydroxide solution was added.
A gas was produced that indicates that ammonium ions are in the mixture.

Complete the sentence.

The gas was ________________________________ which turns

damp red ____ blue.

(2)

(b) Cheshunt mixture is dissolved in water before it is used.
When the student dissolved the Cheshunt mixture in water it formed a blue solution.

(i) Suggest how the student knew that copper ions are in this solution.

____

____

(1)

(ii) The student tested the Cheshunt solution and the result of the test indicated that sulfate ions are in the solution.

Complete the sentence.

The student added a solution of _______________ in the presence of

dilute hydrochloric acid and a _______________ precipitate was produced.

(2)

(Total 7 marks)

Q10.

Methylated spirit is a useful product made from a mixture of substances.

The table below shows the mass of the substances in a sample of methylated spirit.

Substance	**Mass in grams**
Ethanol	265.5
Methanol	23.3
Pyridine	3.0
Methyl violet	1.5

(a) What name is given to a useful product such as methylated spirit?

____

(1)

(b) Calculate the percentage by mass of methanol in methylated spirit.

Use the table above.

____

____

____

____

Percentage = ____________________ %

(2)

Methylated spirit contains ethanol and is available cheaply.

Methylated spirit also contains:

- pyridine which has a very unpleasant smell
- methyl violet which makes the mixture purple.

(c) Suggest why pyridine and methyl violet are added to ethanol to make methylated spirit.

(1)

(d) Suggest **one** use of methylated spirit.

(1)

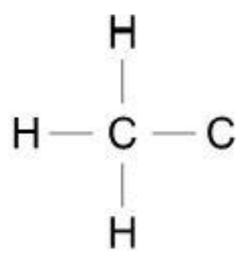
(e) Describe how ethanol is produced from sugar solution.

Give the name of this process.

(3)

(f) The diagram below shows part of the displayed formula for ethanol.

Complete the diagram.



(1)

(g) Name the gas produced when sodium is added to ethanol.

(1)

(h) Methanol is used to produce methanoic acid.

What type of substance reacts with methanol to produce methanoic acid?

(1)
(Total 11 marks)