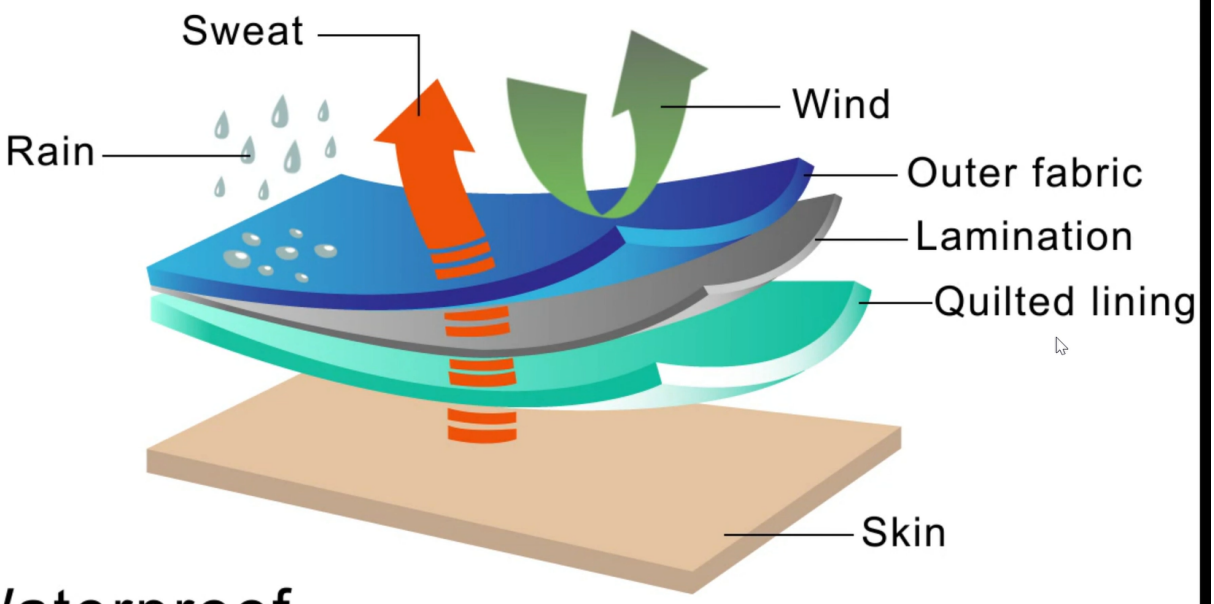
Question 1 (8 marks)

The main role of clothing is protection against the weather. In cold countries natural materials such as wool and fur have traditionally been used but today man-made fibres can be used to trap body heat. Extra warmth can be provided by chemical reactions.

Hand warmers contain iron powder which releases energy when exposed to oxygen in the presence of a catalyst.

The equation for the reaction is:

$$4Fe + 3O_2 \rightarrow 2\,Fe_2O_3$$



Waterproof

how the properties of materials can be used to give greater functionality.

Hand warmers contain iron powder which releases energy when exposed to oxygen in the presence of a catalyst.

The equation for the reaction is:

$$4Fe + 3O_2 \rightarrow 2\ Fe_2O_3$$

Question 1a (1 mark)

State the name given to a reaction in which heat is released.

Hand warmers contain iron powder which releases energy when exposed to oxygen in the presence of a catalyst.

The equation for the reaction is:

$$4Fe + 3O_2 \rightarrow 2\,Fe_2O_3$$

Question 1b (3 marks)

Using the periodic table, **calculate** how many moles of oxygen are needed to oxidize a hand warmer containing 5.6g of iron.

B I U x_2 x^2 Ω Σ Styles

Hand warmers contain iron powder which releases energy when exposed to oxygen in the presence of a catalyst.

The equation for the reaction is:

$$4Fe + 3O_2 \rightarrow 2\,Fe_2O_3$$

Question 1c (1 mark)

State the type of bonding in iron oxide.

Question 1d (1 mark)

Using the periodic table, **state** the charge of the iron ion in Fe_2O_3.

B I U x_2 x^2 Ω Σ Styles

Hand warmers contain iron powder which releases energy when exposed to oxygen in the presence of a catalyst.

The equation for the reaction is:

$$4Fe + 3O_2 \rightarrow 2\ Fe_2O_3$$

Question 1e (2 marks)

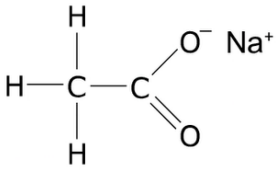
Select one other element that forms ions with the same charge as iron in Fe_2O_3.
Justify your answer.

- sodium
- carbon
- aluminium
- calcium

B I U x_2 x^2 Ω Σ Styles

Question 2 (10 marks)

Reusable hand warmers do not use iron but contain a saturated aqueous solution of sodium ethanoate (CH_3COONa) that releases heat when it undergoes the reversible process of crystallization.



Sodium ethanoate

sodium ethanoate + water ⇌ sodium ethanoate crystals + heat

Question 2a (2 marks)

State and **justify** whether crystallization is a physical or a chemical process.

Question 2b (2 marks)

Outline how a saturated solution is produced.

Question 2c (2 marks)

Outline how the hand warmer can be reused.

Question 2d (4 marks)

Sodium ethanoate is the salt made in the neutralization reaction between ethanoic acid and a strong base.

Determine which base was used and **write down** a chemical equation for this neutralization reaction.

B I U x_2 x^2 Ω Σ Styles

Question 3 (11 marks)

Fossil fuels and factory emissions are some of the main causes of environmental pollution. Unfortunately the damaging effects of pollution spread beyond industrialized areas and can be worsened by extreme climates. The ground in some countries is covered in heavy snow in the winter. When the snow melts in the spring, for a short time, the rivers and lakes will become more acidic.

Question 3a (8 marks)

Explain a problem associated with acid rain. Use scientific knowledge and understanding to support your answer.

B I U x_2 x^2 Ω Σ Styles

Chemists have created catalytic clothing that combines functionality with fashion. Catalytic clothing technology uses nano-sized titanium oxide TiO_2 particles that act as photocatalysts. The photocatalysts help reduce pollutant gases such as nitrogen oxides and sulfur oxides. Pollutant gases have a negative effect on ecosystems and present a risk to humans.

The catalysts are woven into clothes and help to remove pollutants by converting them into soluble compounds that are removed by washing.

Question 3b (1 mark)

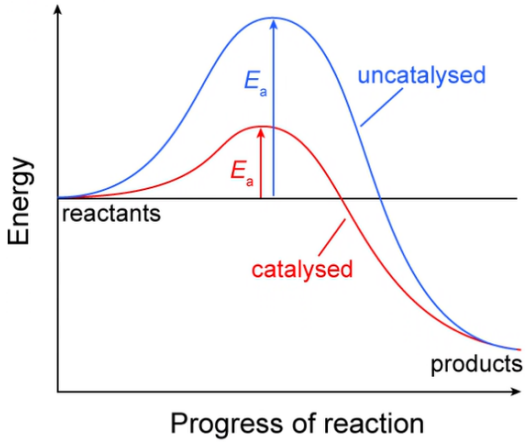
State the meaning of the term ***catalyst***.

Styles

Seek

Question 3c (2 marks)

The graph below is an energy profile diagram which shows the energy changes for both a catalysed reaction and an uncatalysed reaction.



Using the graph, **outline** how catalysts work.

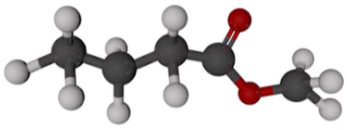
Styles

Question 4 (3 marks)

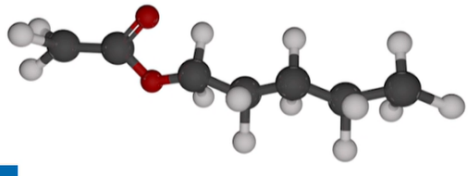
The aroma of fruits comes from characteristic chemicals. For example, the aroma of an apple is mainly caused by molecules of $C_3H_7COOCH_3$ (methyl butanoate) and the aroma of pears by molecules of $CH_3COOC_5H_{11}$ (pentyl ethanoate).

Click ▶ to show the 3d model rotating, click "2d" to show a 2d structure.

2d



2d



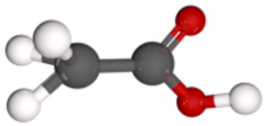
Question 4a (1 mark)

In a futuristic clothing project, two students suggest using methyl butanoate and pentyl ethanoate to form new aromatic fabrics. **State** the class of chemical compound these molecules belong to.

Pentyl ethanoate is formed in a reaction between an acid and an alcohol.

Click ► to show the 3d model rotating, click "2d" to show a 2d structure.

2d



2d

Question 4b (1 mark)

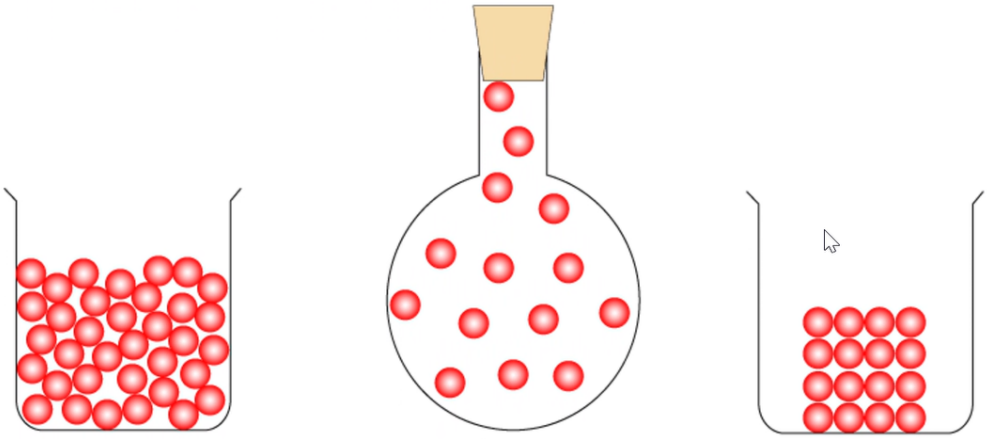
State the name of the alcohol.

Question 4c (1 mark)

State the name of the small molecule lost when the acid and the alcohol above react to form pentyl ethanoate.

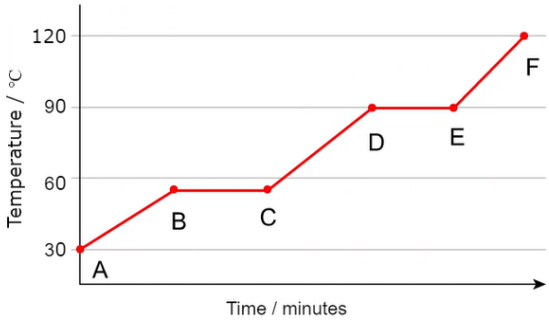
Question 5a (1 mark)

Label the three states of matter shown in the diagrams.



select ▾ select ▾ select ▾

The diagram below shows the state changes for a pure substance which is a solid at 30 °C.



Select the correct description for each of the stages.

Use kinetic theory to **explain** what is happening to the particles in the pure substance.

Question 5b (3 marks)

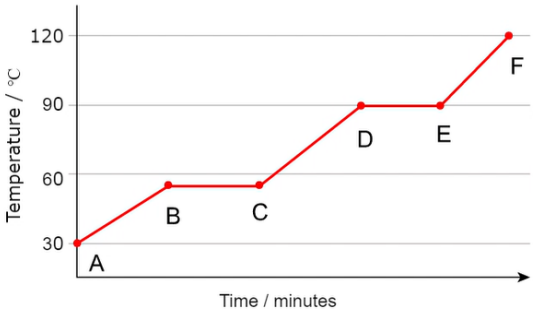
B to C

description : select ▾

What is happening to the particles?

B I U x_2 x^2 Ω Σ Styles

The diagram below shows the state changes for a pure substance which is a solid at 30 °C.



Question 5c (3 marks)

E to D

description : select

What is happening to the particles?

Styles

Question 6 (27 marks)

Water is a compound made from two different elements bonded together.

Question 6a (1 mark)

State the two elements in water.

Element one:

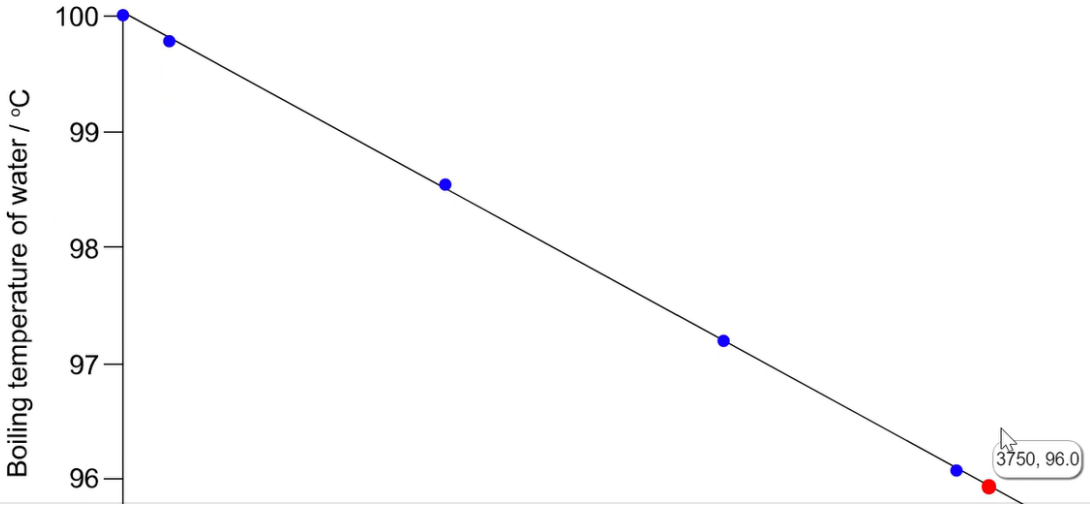
Element two:

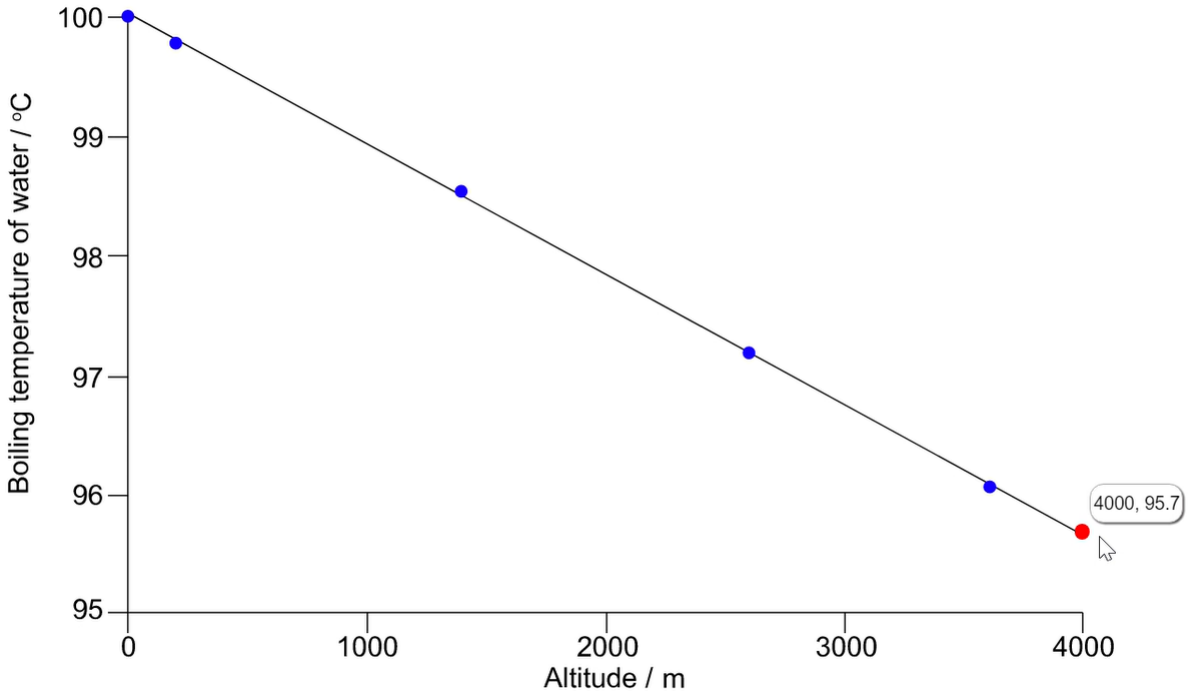
Question 6b (2 marks)

Use particle theory to **outline** what is happening to the particles when a substance boils.

Styles

The boiling temperature of water at standard pressure is 100 °C. The table shows the boiling temperature of water measured at different IB schools. IB schools are located at different heights above sea level. The height above sea level is known as altitude and it can be measured in metres.





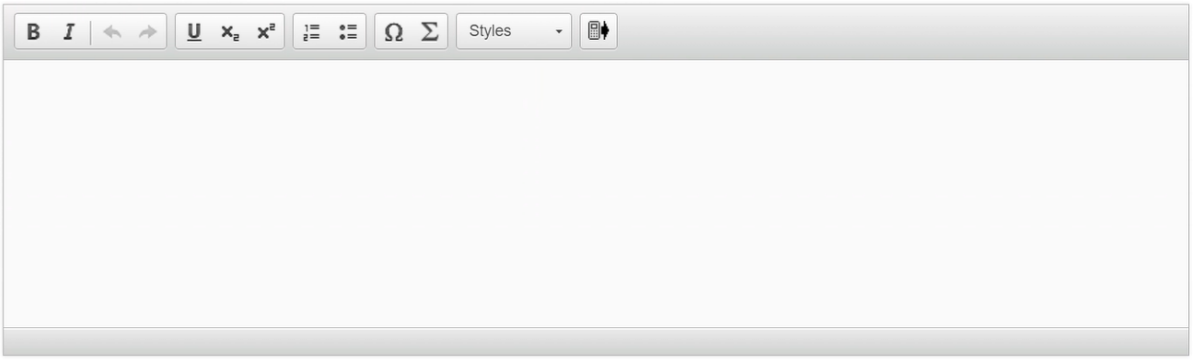
Question 6c (3 marks)

Using the graph, **write down** values to complete the table.

Location	Altitude / m	Boiling temperature of water / °C
Bangkok	1	100.0
Belgrade		99.8
Bogota	2625	97.2
Canberra	605	
Kathmandu	1400	98.6
La Paz	3640	96.1
Nairobi		98.0
New Delhi	210	99.8
Tehran	1138	

Question 6d (1 mark)

State a suitable hypothesis that could be tested using the data in the table.



Question 6e (4 marks)

Some new IB schools at different locations would like to add data to the table.

Identify the variables.

independent variable

Question 6f (16 marks)

Design a method to investigate the boiling temperature of water at different altitudes. In your answer include:

- a hypothesis that your method will test
- how you will manipulate the variables
- a diagram of how you will arrange your equipment
- how you will collect sufficient data
- how you will ensure your method is safe.

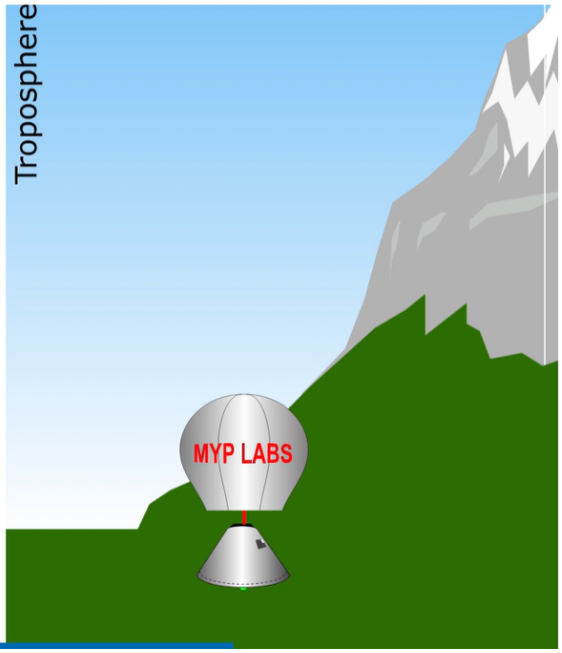
B I U x_2 x^2 Ω Σ Styles

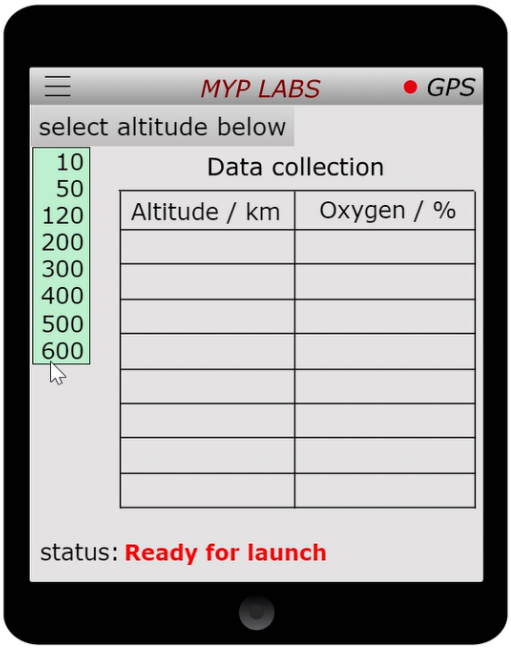
Question 7 (14 marks)

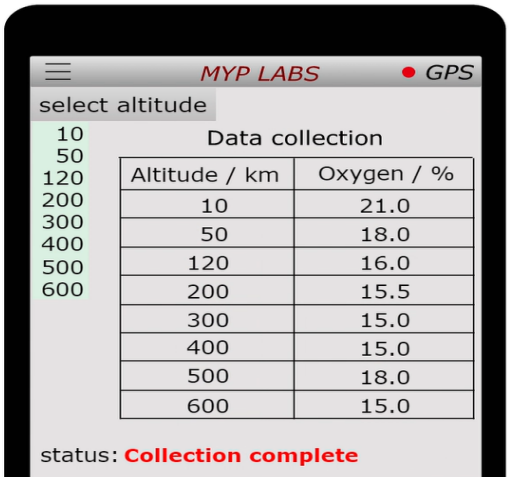
Use the simulation to collect samples of gas from each of the required parts of the atmosphere in the table below. Record the percentage of oxygen obtained at each level.

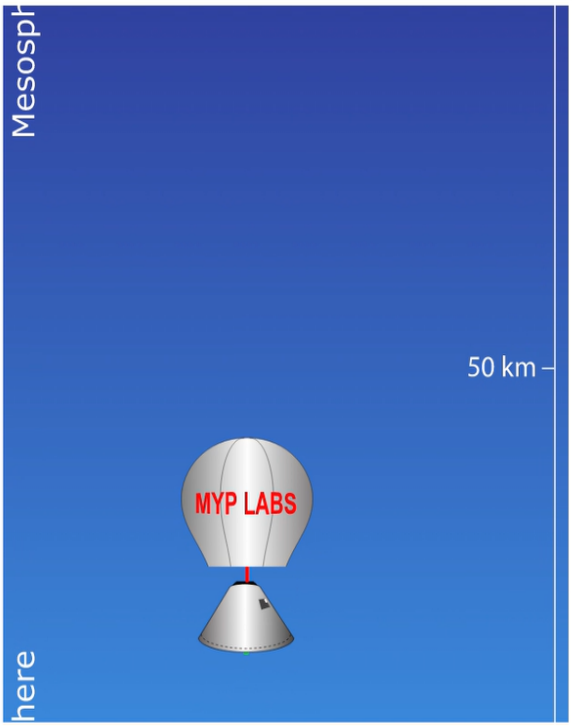
Question 7a (5 marks)

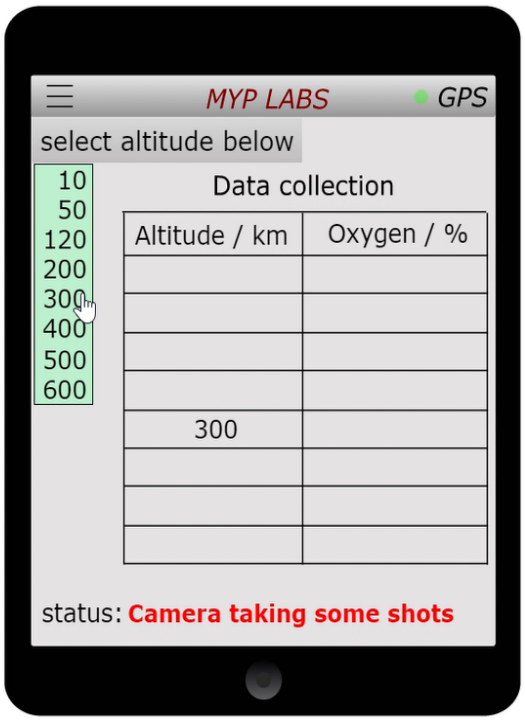
Simulation | Completed results

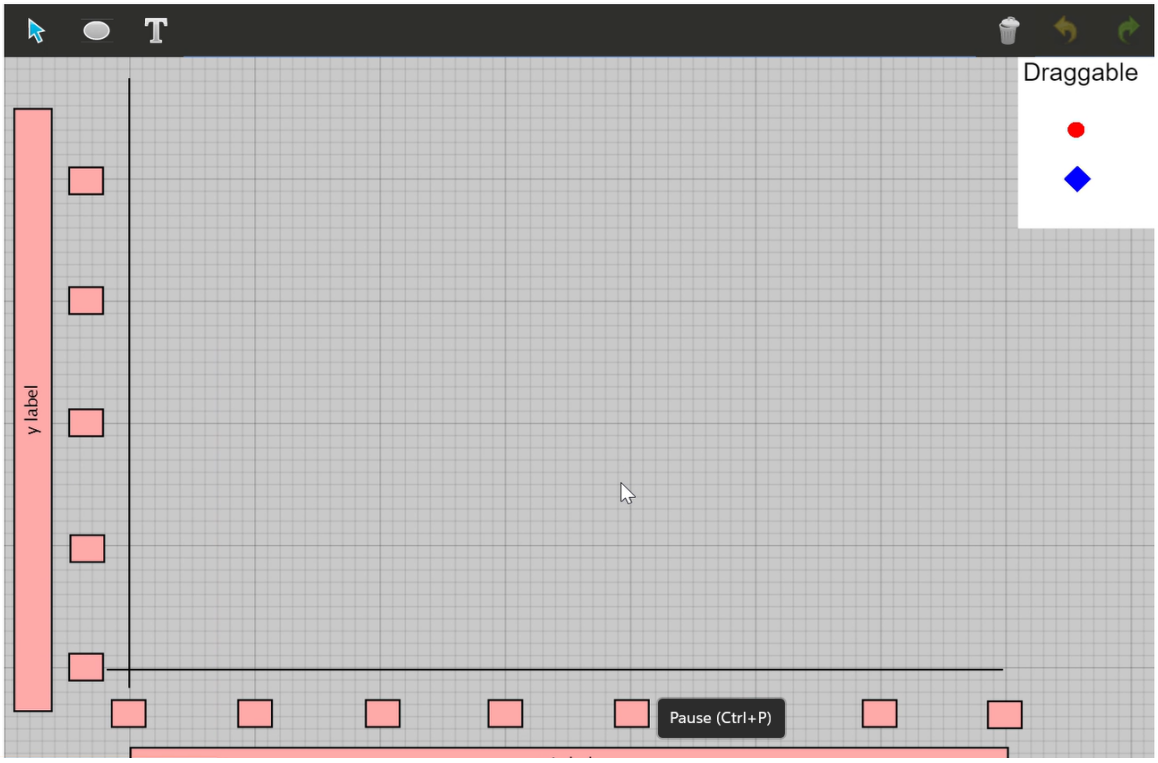





MYP LABS
GPS
select altitude
10
50
120
200
300
400
500
600
Data collection
Altitude / km
Oxygen / %
10
21.0
50
18.0
120
16.0
200
15.5
300
15.0
400
15.0
500
18.0
600
15.0
status: Collection complete


Mesosph
50 km
MYP LABS
here


MYP LABS
GPS
select altitude below
10
50
120
200
300
400
500
600
Data collection
Altitude / km
Oxygen / %
300
status: Camera taking some shots



Question 8 (5 marks)

In July 2014, NASA announced that they will be sending a new rover to Mars. Seven experiments will be included on the rover. One of the experiments is called MOXIE (**M**ars **OX**ygen **I**n-situ resource utilization **E**xperiment). MOXIE will convert the Martian atmosphere, which is approximately 96% carbon dioxide, into oxygen.

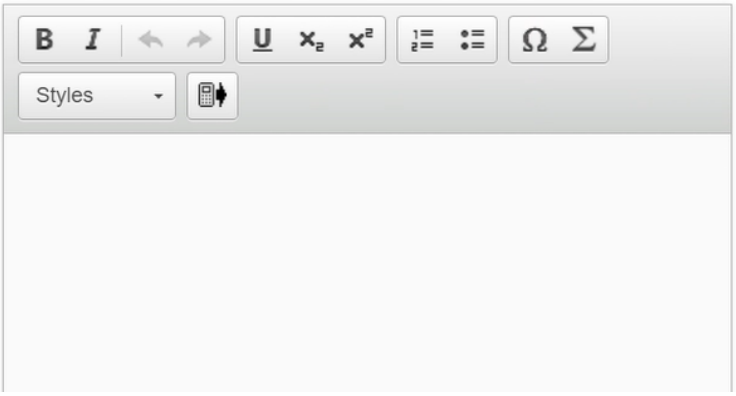
The word equation for the chemical reaction that will take place is

carbon dioxide → oxygen + carbon monoxide

Write down the word equation above as a balanced chemical equation and add state symbols.

Question 8b (2 marks)

Outline the uses of oxygen and why it is important that NASA produces oxygen on Mars.



Question 9 (7 marks)

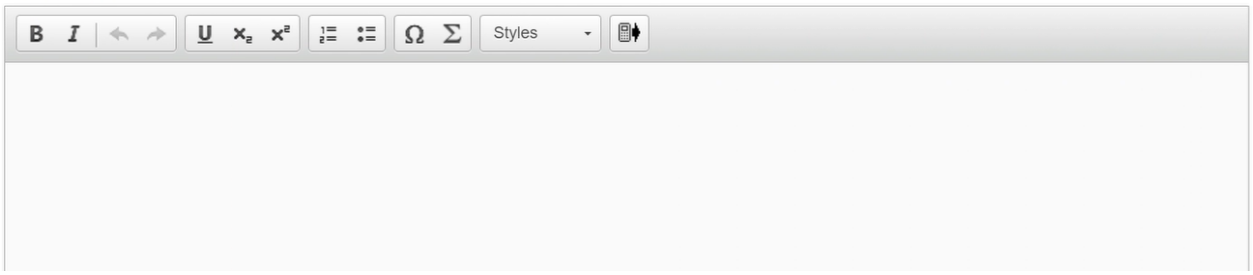
Common salt, NaCl, is used in cooking but many other salts also have important uses in food. The table shows a list of salts used as food additives, their taste and their other uses.

ammonium chloride	salty and quite bitter	in licorice and in baking to give cookies a very crisp texture
calcium chloride	salty and bitter	maintains crispness and firmness of fruits and vegetables
magnesium chloride	salty and bitter	in tofu as a thickener
potassium chloride	salty and slightly bitter	a substitute for sodium chloride
sodium chloride	salty	a flavouring and a preservative

Using information from the table, a student hypothesized "*The salty taste of salts is caused by the presence of a group one ion.*"

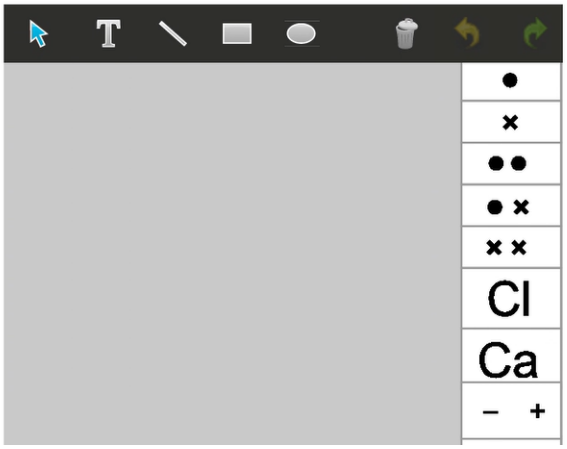
Question 9a (4 marks)

Comment on the validity of the hypothesis above. Use scientific reasoning to support your answer.



Question 9b (1 mark)

Draw a Lewis (electron dot or dot cross) structure showing the electron configuration of $CaCl_2$.

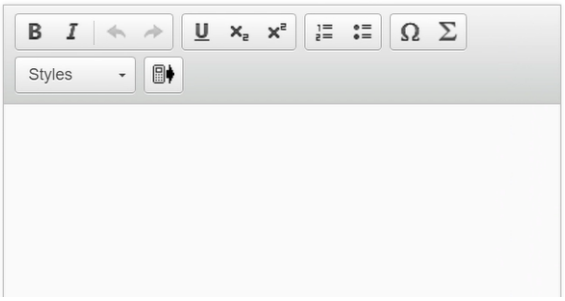


Question 9c (2 marks)

Calcium has 24 isotopes but only five are stable:

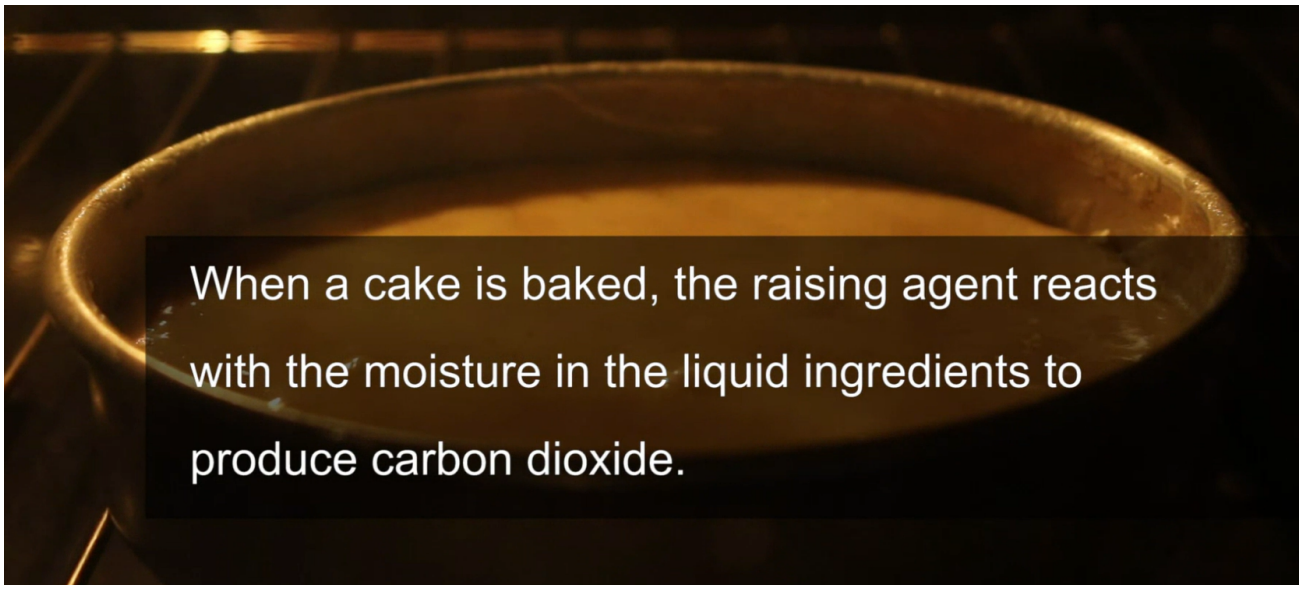
$^{40}_{20}Ca$, $^{42}_{20}Ca$, $^{43}_{20}Ca$, $^{44}_{20}Ca$, and $^{46}_{20}Ca$

Calculate the average number of neutrons of the five isotopes of calcium.



Question 10 (9 marks)

Sodium hydrogen carbonate, $NaHCO_3$, is used in cooking as a raising agent. When a cake is baked, the raising agent reacts with the moisture in the liquid ingredients to produce carbon dioxide. The carbon dioxide produced causes the cake to rise and gives the characteristic texture and grain.



The thermal decomposition of baking soda is an endothermic reaction. It is shown by the following equation:

$$2\ NaHCO_3(s) + \text{heat} \rightarrow Na_2CO_3(s) + H_2O(l) + CO_2(g)$$

The thermal decomposition of $NaHCO_3$ is used in some fire extinguishers. These extinguishers are very effective in extinguishing oil, grease and electrical fires. The carbon dioxide that is released prevents combustion. The carbon dioxide smothers the fire as it is more dense than air.

Question 10a (4 marks)

Explain why a carbon dioxide fire extinguisher is more appropriate than just water for an oil, grease or electrical fire.

Sodium hydrogen carbonate is an amphoteric salt which means that it can react with both strong acids and strong bases. Many bad odours are caused by acidic substances for instance sour milk and rotting fish.

Question 10b (1 mark)

Suggest how sodium bicarbonate could react with either sour milk or rotting fish to remove the bad aroma.

The hydrogen carbonate ion is in equilibrium with water as shown in the following equation:

$$HCO_3^-(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq) + OH^-(aq)$$

Question 10c (4 marks)

Explain how adding an acid would affect the equilibrium above and would affect the quantity of H_2CO_3 present.

B I U x_2 x^2 Ω Σ Styles

Question 11 (16 marks)

The dessert known as **JELL-O®**, *gelatin dessert*, was created in the 19th century in the United States. When **JELL-O®** is manufactured, gelatine is dissolved in hot water with sugar, citric acid, artificial flavour and colouring. Once cooled below 15 °C the **JELL-O®** slowly forms a gelatine network which holds a liquid such as water or juice.

Video List of Ingredients

Question 11a (2 marks)

Discuss why gelatine networks can become unstable when the temperature rises above 15 °C.

Video | List of Ingredients

This graphic is interactive

Ingredient	% Mass	
Powdered gelatine	7.0%	
Sugar	90.0%	
Citric acid	1.8%	
Artificial stabilizer	0.2%	
Artificial colourings	0.7%	
Artificial flavouring	0.3%	

Question 11a (2 marks)

Discuss why gelatine networks can become unstable when the temperature rises above 15 °C.

Styles

Question 11b (2 marks)

Use the list of ingredients to **determine** how to produce a colourless drink with the taste of oranges.

needed	not needed	ingredients
○	○	sugar
○	○	adipic acid
○	○	citric acid
○	○	colouring
○	○	gelatine
○	○	artificial flavour
○	○	water

Question 11c (12 marks)

Discuss and **evaluate** either a social implication or an ethical implication of using additives such as sugar and artificial colourings in the preparation of food.
You should use scientific reasoning to support your answer and consider:

- the benefits of food additives
- the limitations of food additives
- the effects of food additives on an individual and a community
- your appraisal of whether or not additives should be used in the preparation of food.