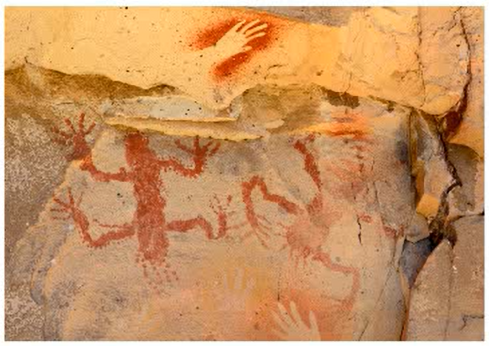
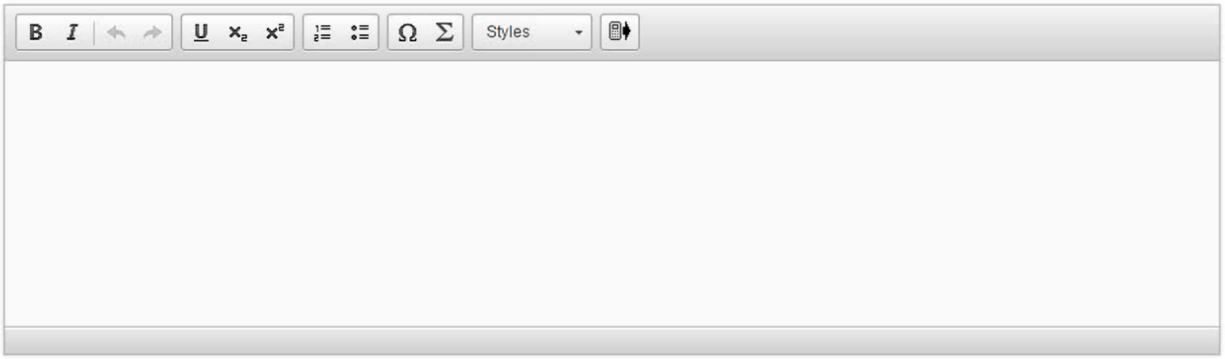
Question 1 (18 marks)

Cave paintings drawn 100 000 years ago have been found in South Africa. These cave paintings were drawn with iron (III) oxide, manganese dioxide and charcoal (black porous carbon). Manganese dioxide has also been used for body painting.



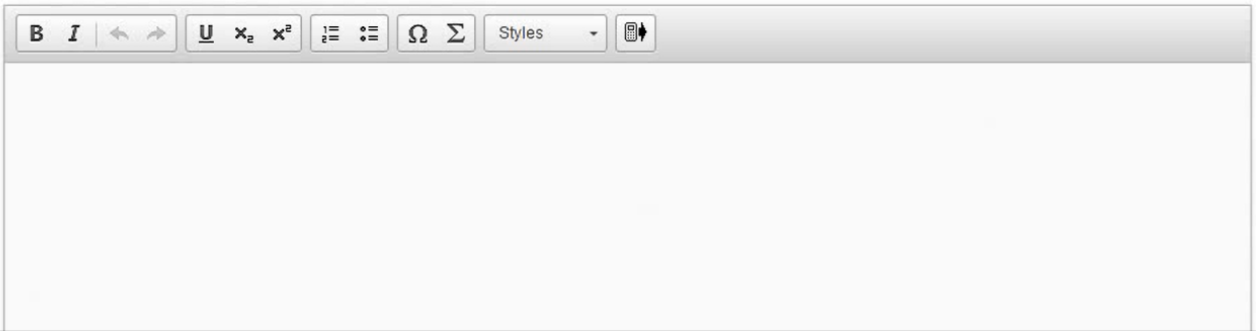
Question 1a (2 marks)

State the chemical formulas of iron (III) oxide and manganese dioxide.



Question 1b (3 marks)

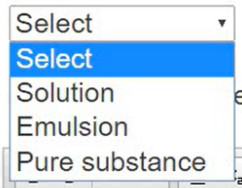
Use the periodic table to **identify** another element that could have the same properties as iron or manganese. **Justify** your answer.



Question 1c (2 marks)

The colour of paint comes from pigments that can be either natural or synthetic. Natural pigments are made by crushing minerals into a fine powder and adding them to water, oil or another liquid along with solvents and additives.

Identify whether paint is a solution, an emulsion or a pure substance.



er.

Question 1c (2 marks)

The colour of paint comes from pigments that can be either natural or synthetic. Natural pigments are made by crushing minerals into a fine powder and adding them to water, oil or another liquid along with solvents and additives.

Identify whether paint is a solution, an emulsion or a pure substance.

Select

Justify your answer.

B I U x_2 x^2 Ω Σ Styles

Question 1d (3 marks)

Outline why it is usually easier to remove watercolour paint than oil paint by washing.

B I U x_2 x^2 Ω Σ Styles

Question 1e (4 marks)

Use the information from this question to **evaluate** which type of paint causes less damage to the environment.

B I U x_2 x^2 Ω Σ Styles

Question 1f (2 marks)

Researchers have recently found out that in certain Van Gogh paintings, sunlight has caused a chrome yellow colour to change to a green colour. The sunlight oxidises the oil in the paint, releasing electrons. These free electrons are then captured by the yellow chromate ions (CrO_4^{2-}) in the pigment. The chromate ions turn to green due to the formation of chromium oxide (Cr_2O_3).

We can explain the change to the colours with the following half-reaction:

$$CrO_4^{2-}(aq) + H^+(aq) + e^- \rightarrow Cr_2O_3(s) + 5\,H_2O(l)$$

(yellow) (green)

Question 2 (9 marks)

Modern photography uses digital technology. In the past, however, chemistry played a major role in producing photographs. Chemistry was important at all stages from coating the film before use to the sensitive reactions in the presence of light which were part of the developing process.

Question 2a (3 marks)

Ethanoic (acetic) acid is often used in traditional photography as a "fixer", a chemical that stops the action of an alkaline developer.

Draw the structural formula of ethanoic acid and **state** the name of the functional group.

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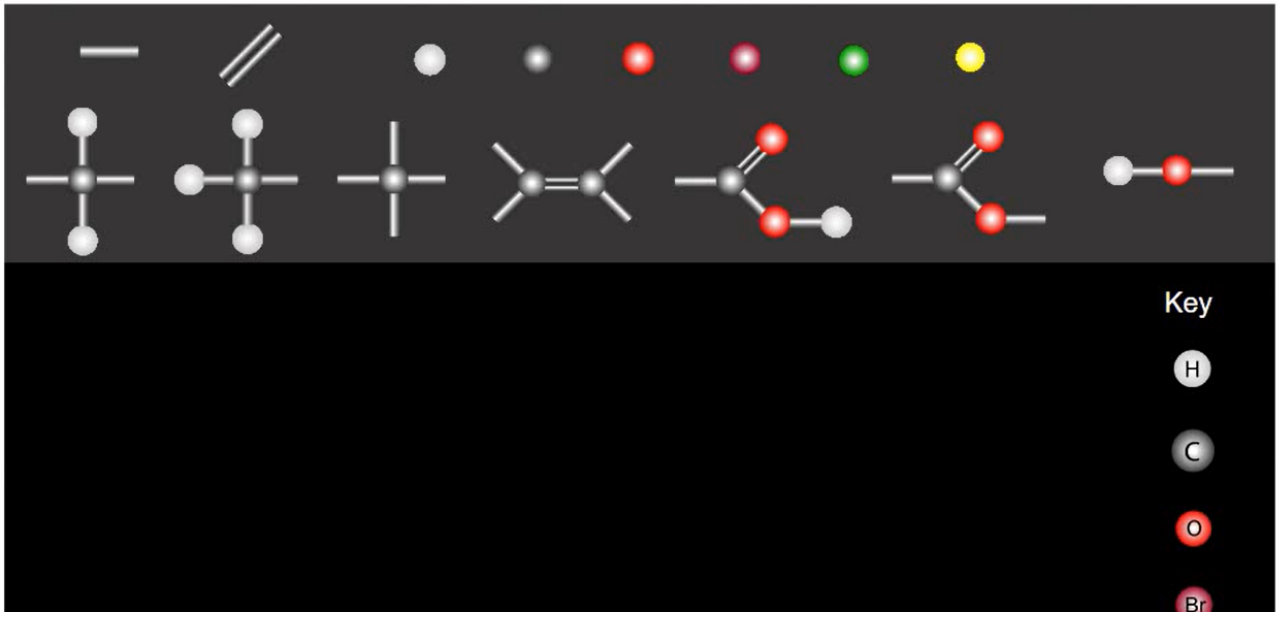


Name of the functional group.

Question 2b (1 mark)

State the type of reaction between the acid and the alkaline developer.

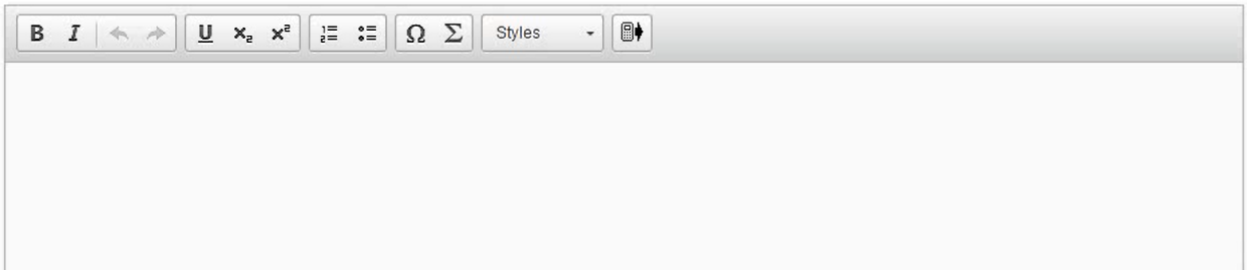
Styles

Question 2c (1 mark)

The following video shows the stages of developing a photograph.

Adding layers of silver atoms will create more and more contrast and that is the reason why the stop bath containing ethanoic acid is needed before all the film becomes black.

The developer is a chemical with a molecular formula of $C_6H_6O_2$. **Calculate** the molecular mass of the developer.

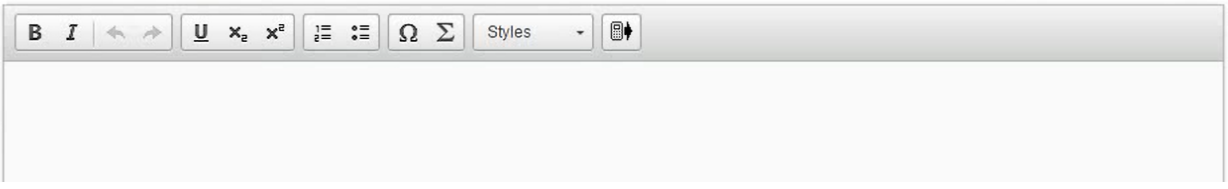


Question 2d (4 marks)

The main reaction in black and white photography can be shown by the following equation

$$2\ AgBr\ (aq)\ +\ C_6H_4O_2{}^{2-}\ (aq)\ \rightarrow\ 2\ Ag\ (s)\ +\ 2\ Br^-\ (aq)\ +\ C_6H_4O_2\ (aq)$$

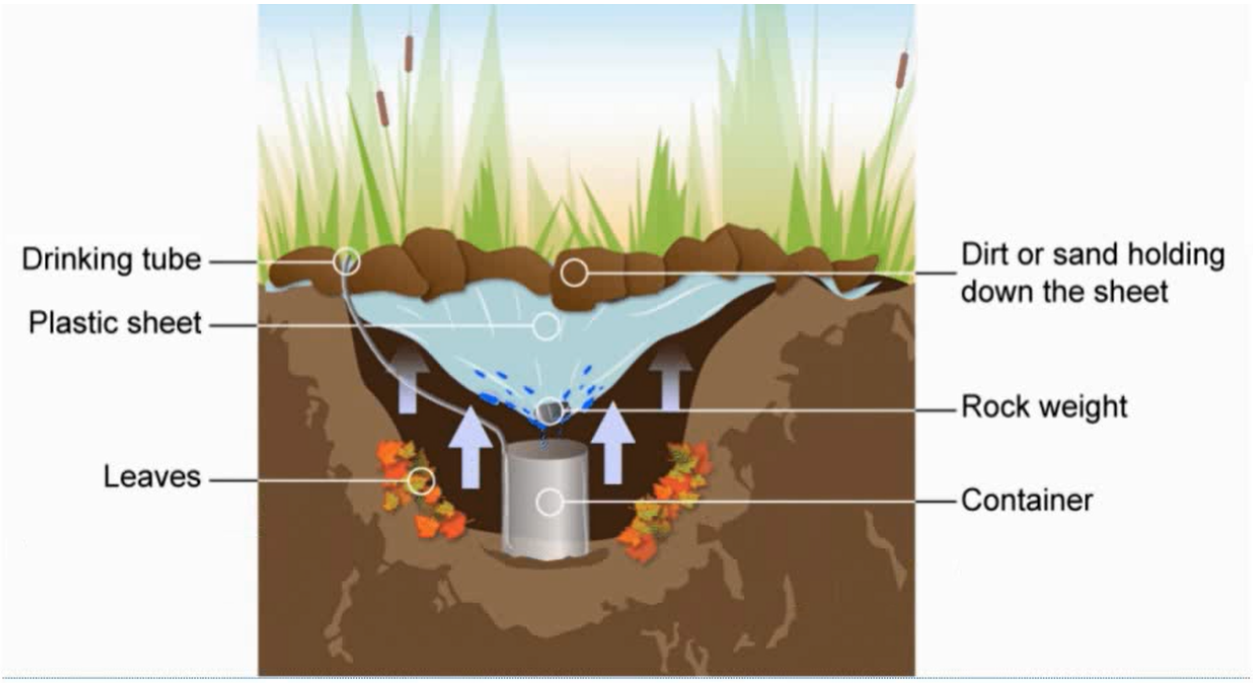
Calculate the mass of AgBr that would be needed to produce 2.0 kg of silver. Give your answer to **two significant figures**.



Question 3 (27 marks)

After a natural disaster people need help to re-establish basic living conditions. In most survival guides, the three basic requirements to survive are water, food and shelter.

Doctors estimate that you can survive for between three and five days without water and much longer without food. Obtaining clean water is a priority for survival. This clean water would have several uses including drinking and cooking.



©

Select the physical process shown in diagram 1.

Select

Select
Condensation
Melting
Boiling
Evaporation
Freezing

cal process shown in diagram 1.

Select

Question 3c (3 marks)

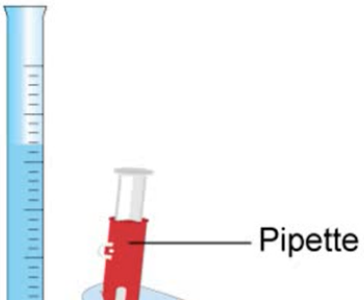
After a disaster, the water available is often contaminated and is not suitable for drinking or cooking. The water must be purified to allow it to be used. The first process is to remove any stones, leaves or smaller particles. The bottle shown below has water which has been collected from a river and the contents labelled.

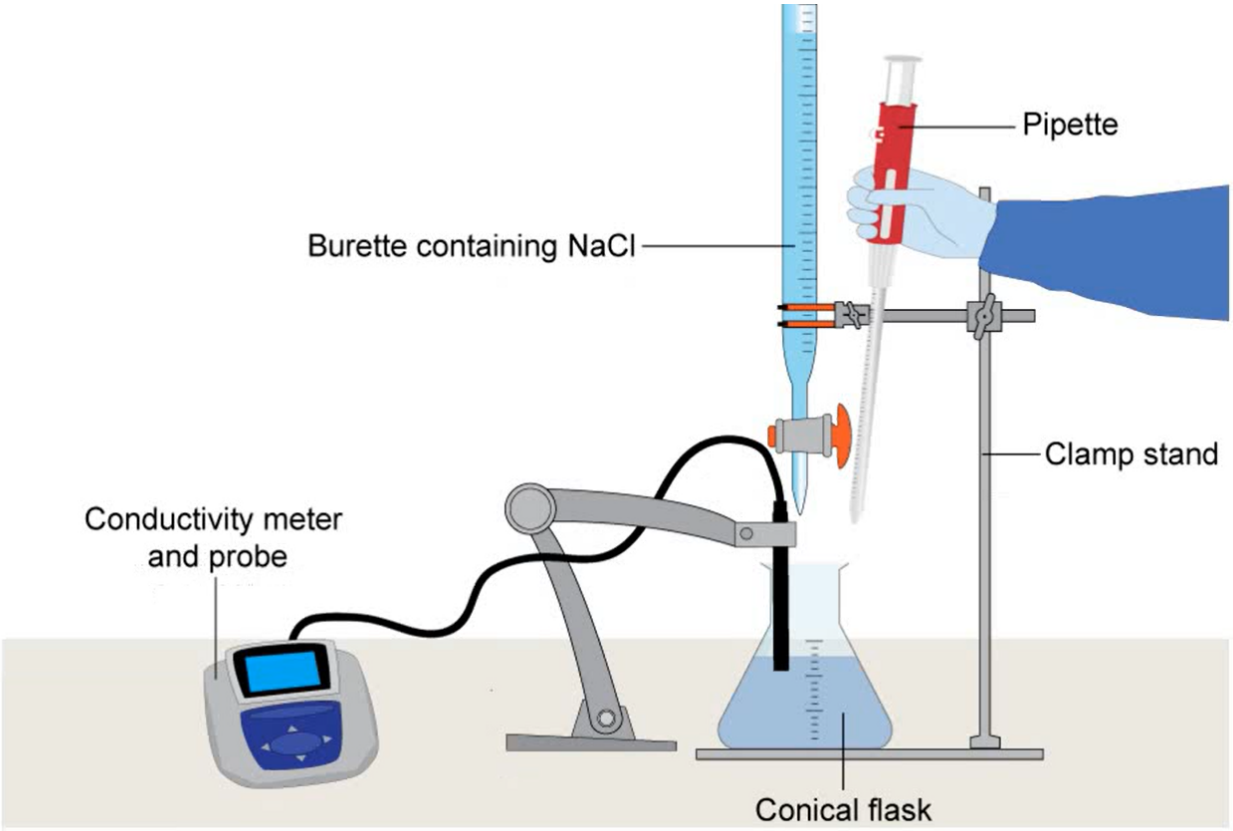
Select and **label** the equipment needed to remove the objects from the dirty water and arrange them for use.

Question 3d (3 marks)

The video gives some information about different types of water filters.

A scientist developing the silver water filter wanted to check that silver ions were not transferred to the water being purified. She decided to test this using a process called titration or volumetric analysis. The scientist used the following apparatus and measured the conductivity of the solution. Conductivity is a measure of how many ions are present in a solution. Conductivity can be measured in millivolts (mV).



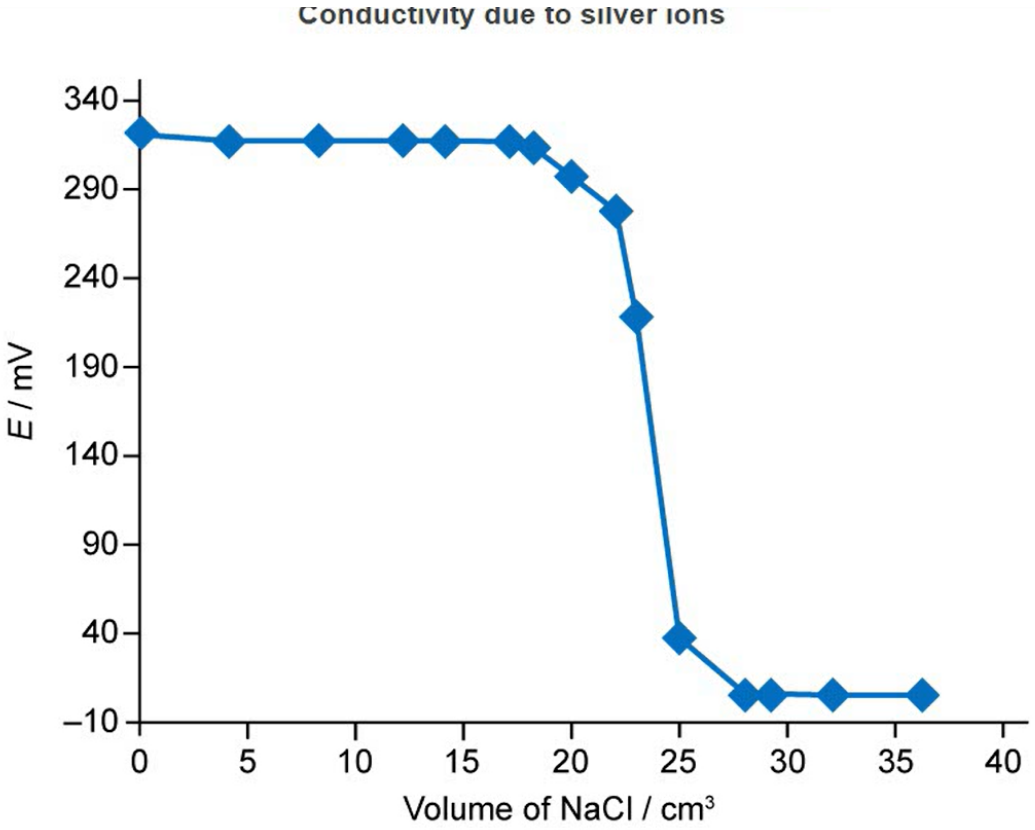


The scientist added sodium chloride solution from the burette to the flask which contained the water treated with the silver filter.

The reaction taking place in the flask is:

$$Ag^{+}(aq) + Cl^{-}(aq) \rightarrow AgCl(s)$$

The scientist recorded the conductivity and her results are shown in the graph below.



Select the correct words to complete the following paragraph.

Select the correct words to complete the following paragraph.

At the start of the experiment the conductivity is Select .

As NaCl is added, the conductivity Select as insoluble AgCl is formed.

This is because there are fewer silv ...resent in the solution.

Select
increases
decreases
remains stable

Select the correct words to complete the following paragraph.

At the start of the experiment the conductivity is Select .

As NaCl is added, the conductivity Select as insoluble AgCl is formed.

This is because there are fewer silver Select present in the solution.

Select
atoms
ions
molecules

Select the correct words to complete the following paragraph.

At the start of the experiment the conductivity is Select .

As NaCl is added, the conductivity Select ble AgCl is formed.

This is because there are fewer silver Select the solution.

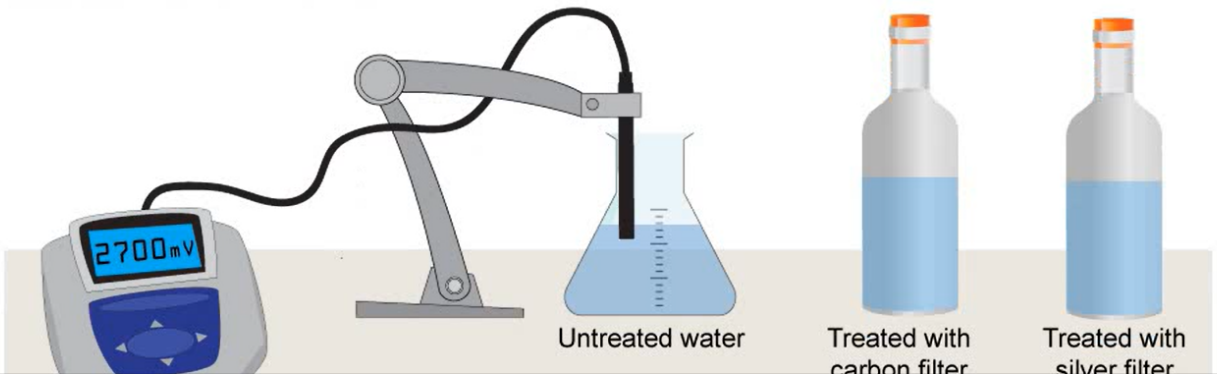
Select
ow
high
increasing
decreasing

Question 3e (2 marks)

State how the conductivity changes when 20–25 cm^3 of NaCl is added. **Suggest** a reason for this change.

Question 3f (2 marks)

During the purification process, microbes need to be removed. Conductivity measurements can be used to evaluate if microbes have been successfully removed. Water with a high concentration of microbes has a high conductivity whereas pure water has a much lower conductivity of 17mV. The image below demonstrates how conductivity measurements can be used to compare water purity.



Identify the variables in an experiment to determine which of the three filters is most effective for purifying water. The independent variable and one control variable have been completed for you.

Independent variable:

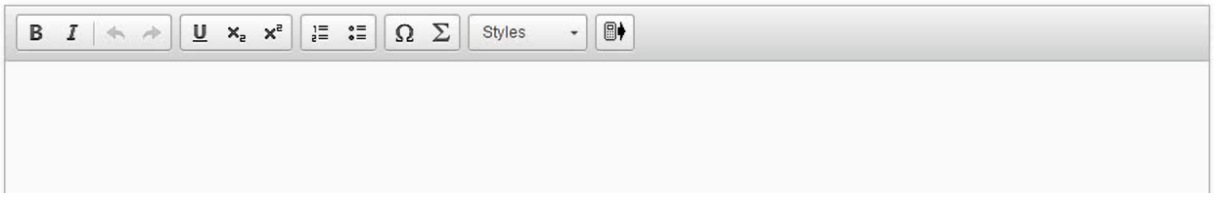
Filter type

Dependent variable:

Question 3g (14 marks)

Design a method to test which water filter is most effective. In your answer you should include:

- your research question
- a description of how you will manipulate and measure the variables in part (f)
- a list of the equipment you will use
- a description of your method
- a description of how you will ensure you collect sufficient data.



Question 4 (21 marks)

In 2015 there was an earthquake in Nepal. Many urban areas were destroyed and there was less commercial fuel available for cooking and heating.

Question 4a (2 marks)

Various fuels are compared in the table below.

Wood | Dung (animal waste) | LPG | Biogas | Crop waste | Kerosene | Charcoal | Electricity

Question 4a (2 marks)

Various fuels are compared in the table below.

Wood | Dung (animal waste) | LPG | Biogas | Crop waste | Kerosene | Charcoal | Electricity

Type of fuel	Percentage of different types of fuel use in an urban area / %	Percentage of different types of fuel use in a rural area / %
Wood	36.2	81.4
Dung (animal waste)	2.5	
LPG		3.9
Biogas	3.2	2.4
Crop waste	0.2	1.8
Kerosene	15.8	1.0
Charcoal	0.2	0.1
Electricity	0.4	0

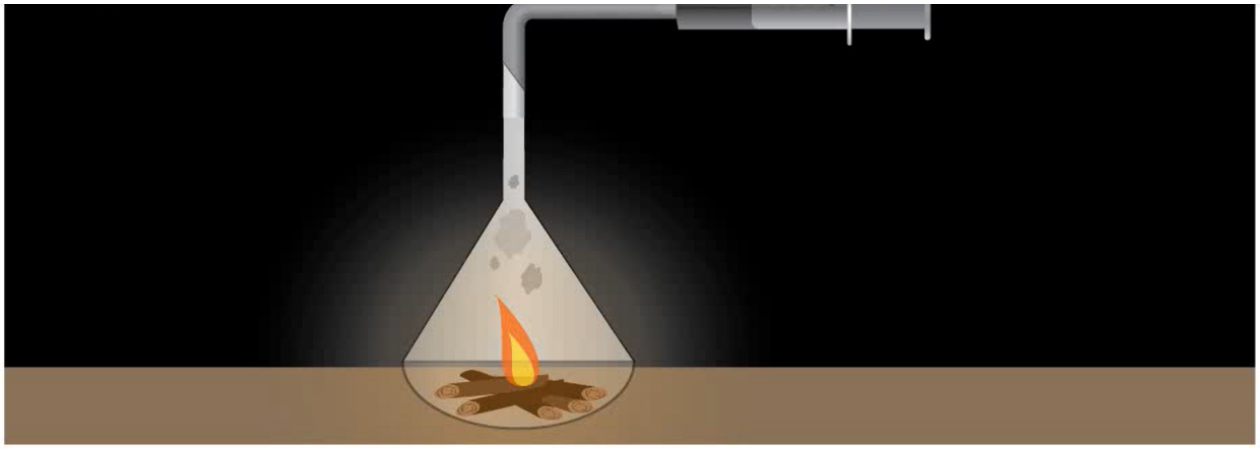
Question 4b (3 marks)

One of the gases produced in the combustion of fuels is carbon dioxide. **Outline** a test for carbon dioxide. Include the name of the chemical needed in your answer.

Question 4c (11 marks)

A student suggested that the two fuels with the highest percentage use in the rural area release different amounts of carbon dioxide and that one would be better for the environment than the other.

The volume of gas produced when a fuel is combusted can be measured using the following equipment.



Design a safe method to determine the volume of gas produced when each of the fuels is combusted using the equipment shown. In your answer you should:

- identify the two fuels that have the highest percentage use in the rural area
- state the dependent variable and a control variable
- outline how you will collect sufficient data
- describe your method
- list any safety considerations.

B I U x_2 x^2 Ω Σ Styles

Question 4d (1 mark)

State the assumption made when using this equipment to collect carbon dioxide.

B I U x_2 x^2 Ω Σ Styles

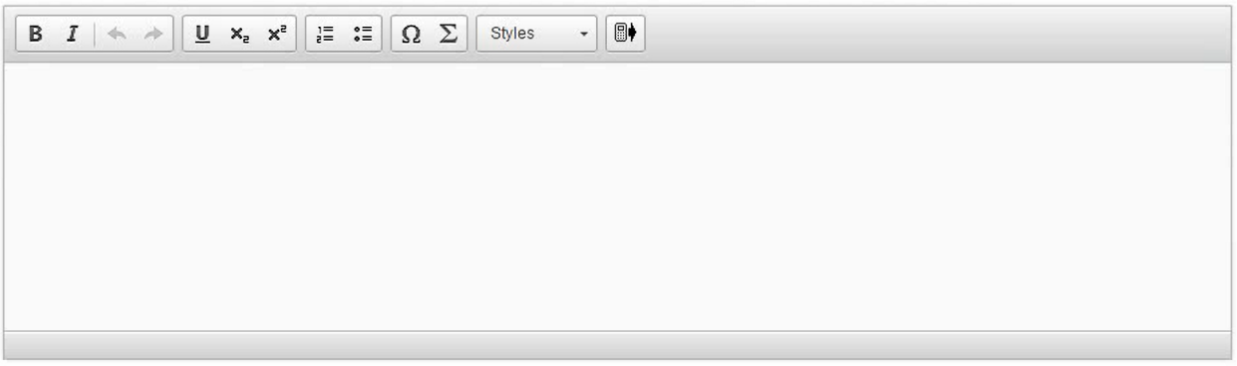
Question 4e (3 marks)

Smoke is also produced when the fuel is combusted.

Comment on how the presence of smoke could affect the validity of the results.

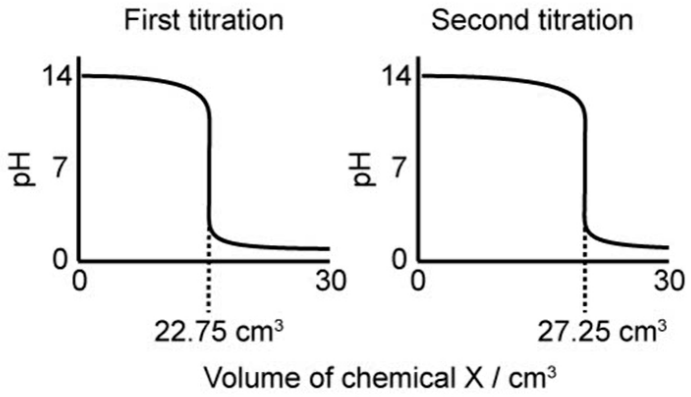
Question 4f (1 mark)

Suggest an improvement to the equipment to prevent the production of smoke.



Question 5 (8 marks)

A titration method using chemical X can also be used to determine the amount of CO_2 released. The results of this experiment are shown in the graphs below.



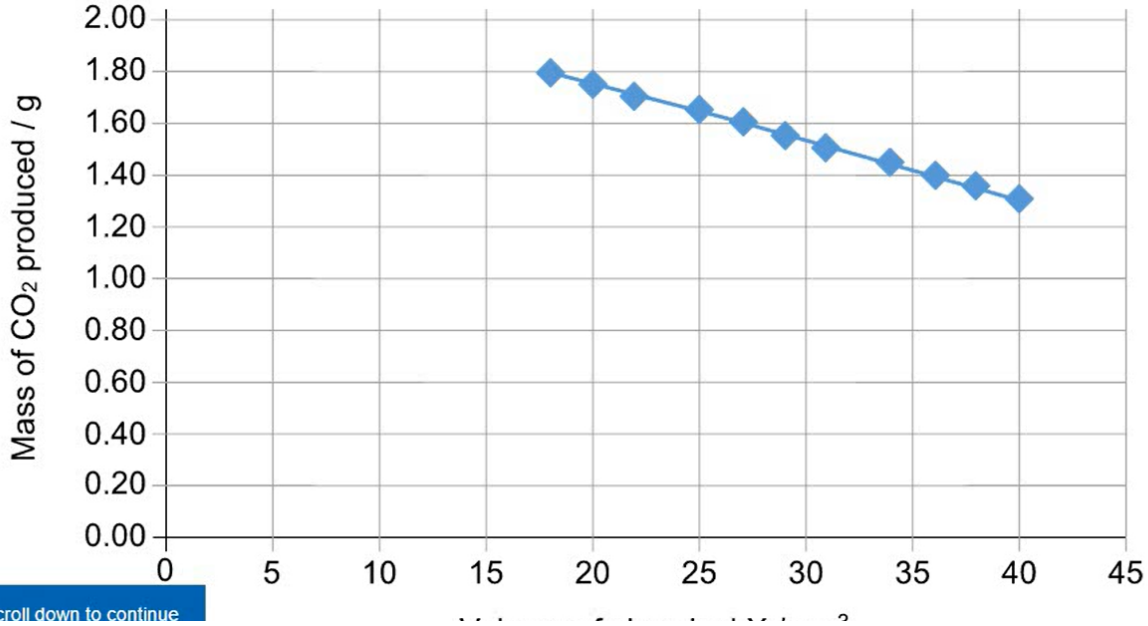
Question 5a (2 marks)

Use the graphs to **determine** the volume of chemical X needed to form a neutral solution and complete the table below.

	Volume of chemical X added
First titration / cm^3	
Second titration / cm^3	
Average amount of chemical X added / cm^3	

Question 5b (2 marks)

The graph below shows the mass of carbon dioxide released against the volume of chemical X used in the titration.



Scroll down to continue

Question 5c (4 marks)

Calculate the volume of carbon dioxide produced for 10 g of wood.
(Molar mass of carbon dioxide is 44 g mol^{-1}, molar volume of a gas = 22.7 dm^3 mol^{-1})

B I U x_2 x^2 Ω Σ Styles

Question 6 (7 marks)

It is known that increased amounts of carbon dioxide and sulfur oxides released by burning forests or farmland can lead to an increase in air pollution. This increase in air pollution can contribute to acid rain.

Acid rain may damage statues containing calcium carbonate ($CaCO_3$) by forming a calcium salt, water and carbon dioxide.

The action of an acid on calcium carbonate can be shown by the following equation:

$$CaCO_3\,(s) + 2\,HCl\,(aq) \rightarrow CaCl_2\,(aq) + H_2O\,(l) + CO_2\,(g)$$

You and a friend have completed an experiment to investigate the rate of reaction between $CaCO_3$ and HCl. The data you have collected is given below.

Room temperature : 22.0 °C
Mass of $CaCO_3$: 0.10 g

Time (sec)	Volume CO_2
10	13.0 cm^3
30	18.4 cm^3
60	19.8 cm^3
80	20.4 cm^3
100	0.0209 dm^3
120	21.1 cm^3
140	21.3 cm^3

Concentration of HCl : 0.25 mol dm^{-3}

Time (sec)	Volume CO_2
20	17.3 cm^3
40	0.0192 dm^3
70	20.1 cm^3
90	20.5 cm^3
110	0.0201 dm^3
130	21.2 cm^3
150	21.3 cm^3

Question 6a (2 marks)

Combine the data from you and your friend. **Organize** and **present** this data in a table.

Time / s	Volume CO_2 / cm^3

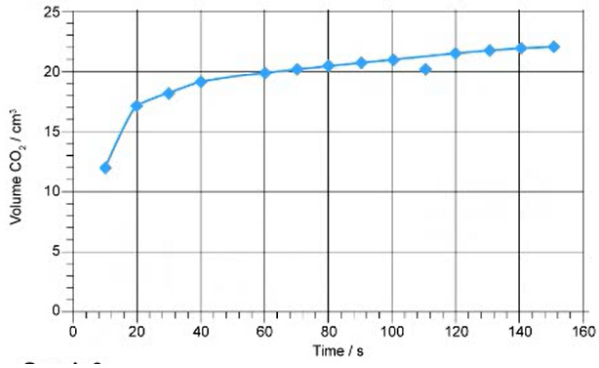
Question 6b (2 marks)

Select the most appropriate graph to present this data. **Label** the graph with a suitable title.

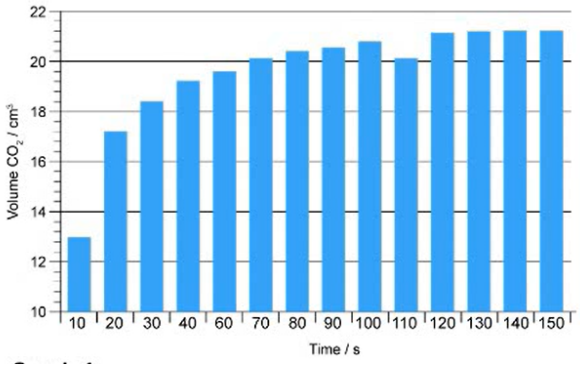
Select

Title

Graph 1

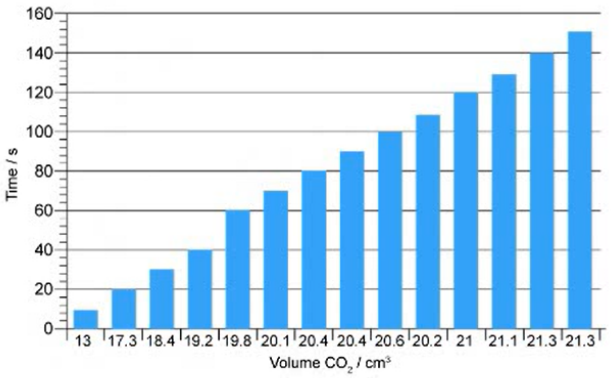


Graph 2



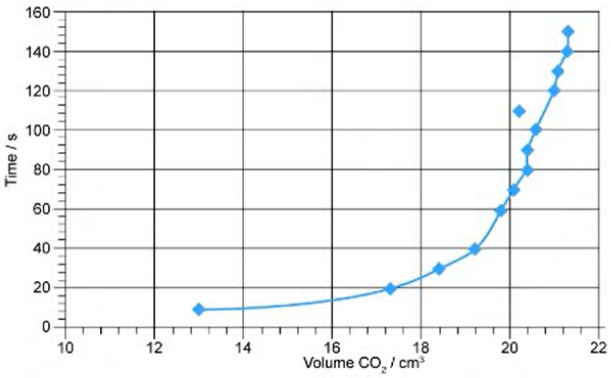
Time / s

Graph 3



Time / s

Graph 4



Question 6c (2 marks)

The graph shows data from one trial only. **Identify** one measurement that does not fit the expected trend. **Estimate** a more likely value for this data point.

B I U x_2 x^2 Ω Σ Styles

Question 6d (1 mark)

Suggest an improvement to this experiment that would increase the validity of the data.

B I U x_2 x^2 Ω Σ Styles

Question 7 (6 marks)

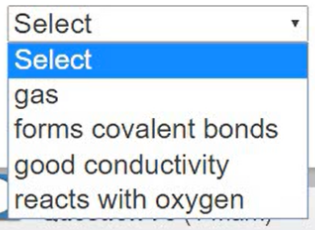
Lead is a very useful metal that has been in use from early times. For a metal, lead has a low melting point and can be easily moulded. Lead can be shaped but does not react with air. These properties make lead suitable for a variety of uses. Lead was used to make pipes that made it possible to carry water as far back as Roman times. In fact this widespread use of lead gave us the word "plumbing" which comes from the Latin word for lead, *plumbum.* History has shown, however, that lead and lead compounds are toxic.

Question 7a (2 marks)

Use the periodic table to **state** the group and period of lead.

Question 7b (1 mark)

Use your knowledge of the periodic table to **select** a property of lead at room temperature and pressure.



Question 7c (1 mark)

State the property of lead that means scientists can study pipes that have survived from Roman times.

Question 7d (2 marks)

Lead has four stable, naturally occurring isotopes. The percentage of each isotope is shown below.

$^{204}_{82}Pb$ 1.4 % $^{206}_{82}Pb$ 24.1 % $^{207}_{82}Pb$ 22.1 % $^{208}_{82}Pb$ 52.4 %

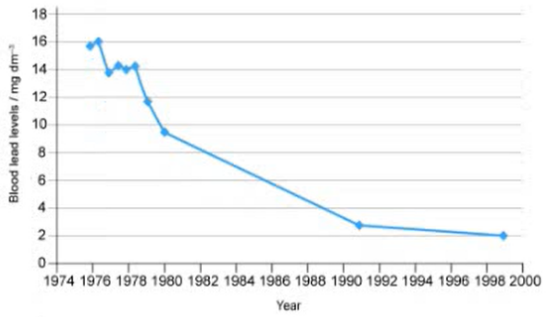
Determine the number of protons and neutrons in

$$^{208}_{82}Pb$$

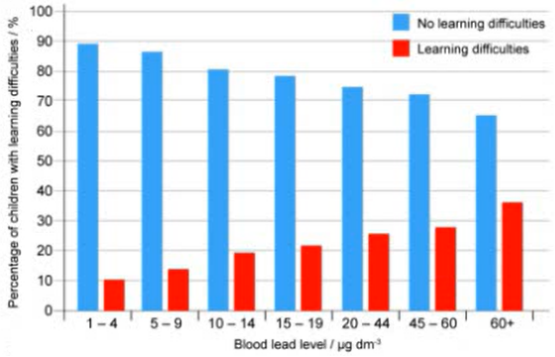
The first graph shows blood lead levels in the US population 1976–1999.

The second graph shows the percentage of children with learning difficulties compared to blood lead level.

Graph 1



Graph 2



Use the information from the graphs to **discuss** the implications of removing lead from paint and other manufacturing processes. In your answer you should discuss:

- the issues around the use of lead
- the blood lead levels of the population
- the impact of blood lead levels on education
- the wider impact on society
- an appraisal of the effect of removing lead from manufacturing processes and use in the home.

Question 9 (10 marks)

Batteries are used in the home in a wide variety of appliances. Almost everyone uses rechargeable batteries in toys, computers and mobile (cell) phones. The earliest rechargeable batteries often used lead to generate an electric current but today, lead has been replaced by different metals.

As technology has developed, the type of batteries in use have evolved to meet consumers' needs taking into account environmental and economic factors. Several types of batteries used in mobile phones and their specifications are shown in the table below.

Types of mobile phone batteries

 **Lithium Polymer (Li-Poly)**	 **Lithium ion (Li-ion)**	 **Nickel Cadmium (NiCd)**	 **Nickel Metal Hydride (NiMH)**
Newest and most advanced technology	Current and most popular technology	Old technology	New technology
Ultra lightweight	Lighter than NiMH	Medium weight	Medium weight

 **Lithium Polymer (Li-Poly)**	 **Lithium ion (Li-ion)**	 **Nickel Cadmium (NiCd)**	 **Nickel Metal Hydride (NiMH)**
Newest and most advanced technology	Current and most popular technology	Old technology	New technology
Ultra lightweight	Lighter than NiMH	Medium weight	Medium weight
No memory effect	Damaged by excessive overcharging for more than 24 hours	Suffer from memory effect, must be completely discharged before recharging	Suffer from slight memory effect. Need to discharge after 20th recharge
Environmentally friendly because the lithium can be recycled	Environmentally friendly because the lithium can be recycled	Not environmentally friendly in terms of disposal of cadmium	Superior to NiCd as they don't contain cadmium. Environmentally friendly
US$100	US$100	US$50	US$60
Can be recharged 300 – 500 times	Can be recharged 500 – 1000 times	Can be recharged 1500 times	Can be recharged 300 – 500 times
2 – 4 hours to charge	2 – 4 hours to charge	1 hour to charge	2 – 4 hours to charge

"Memory effect" happens when rechargeable batteries are not fully discharged between charge cycles; as a result the battery "remembers" the shortened cycle and is thus reduced in capacity.

Using information from the table, **discuss** and **evaluate** mobile phone batteries. In your answer you should:

- identify which type of battery you consider to be the best
- compare your chosen battery with the other batteries
- consider environmental and economic factors
- use data from the table to support your answer
- give a concluding appraisal.