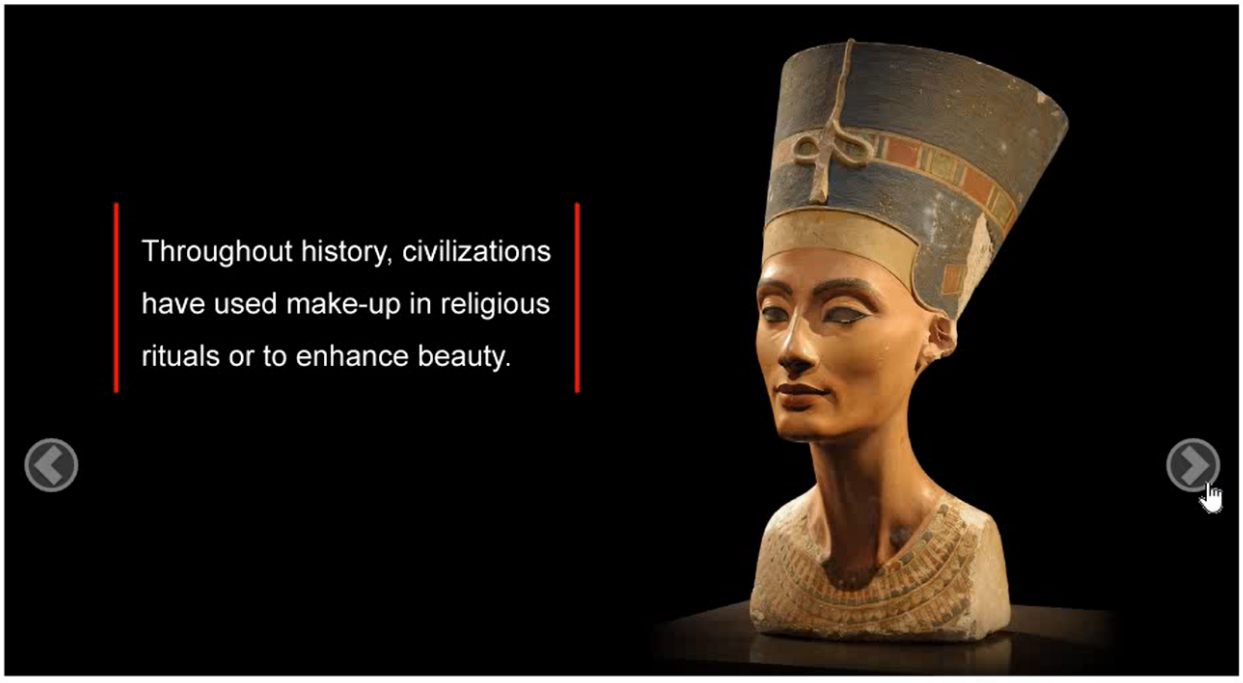
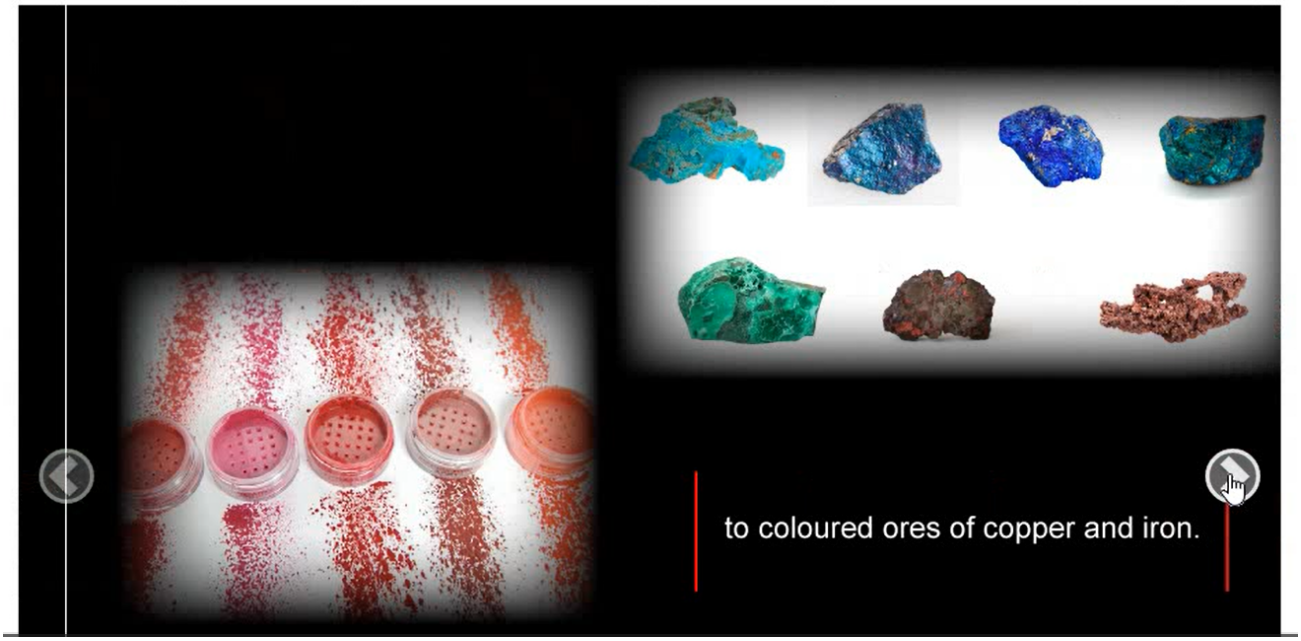
Question 1 (16 marks)

Arsenic and lead were two elements used in ancient Greece to create a paler complexion. We now know that both arsenic and lead are toxic. Arsenic and lead were replaced in the last century by less toxic compounds such as zinc oxide and more recently by complex mixtures of different organic compounds.




Make-up was also used to
indicate social status.

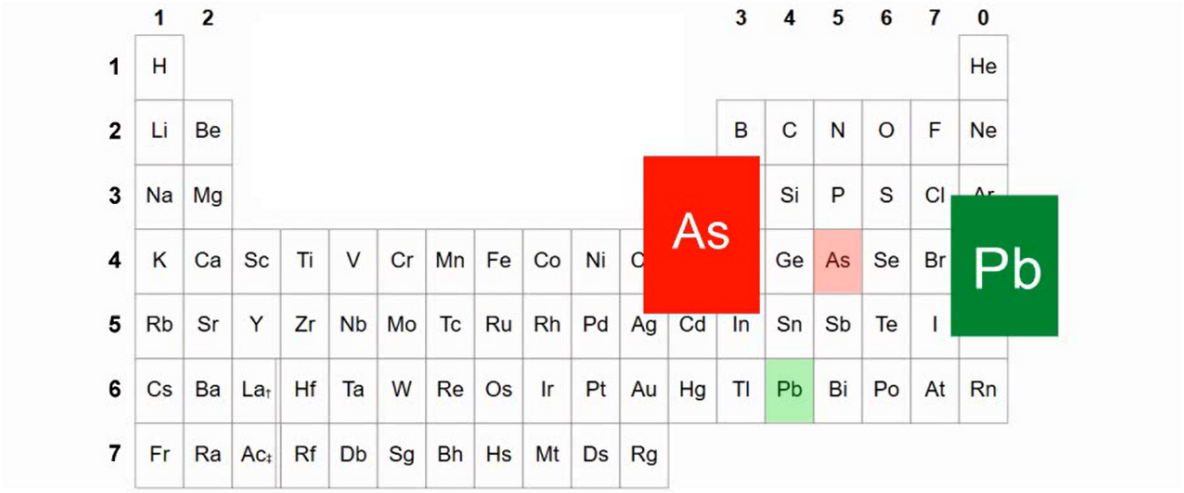

to coloured ores of copper and iron.

Question 1a (2 marks)

Using the periodic table, **state** the group and period of lead.

	1	2											3	4	5	6	7	0
1	H																	He
2	Li	Be											B	C	N	O	F	Ne
3	Na	Mg											Al	Si	P	S	Cl	Ar
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	Cs	Ba	La†	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	Fr	Ra	Ac‡	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg							

Using the periodic table, **state** the group and period of lead.



Group: [ ] Period: [ ]

Question 1b (4 marks)

Lead is normally found as an ore in the Earth's crust. The most common lead ore is galena or lead sulphide (PbS). Lead is extracted by heating the ore to produce lead oxide. The lead oxide is reduced using carbon to produce lead metal according to the equations below. These equations are not balanced.

$$PbS + O_2 \longrightarrow PbO + SO_2$$

$$PbO + C \longrightarrow Pb + CO_2$$

Select numbers to balance the chemical equations. Make sure you select an option for every box.

[?] PbS + [?] O_2 ⟶ [?] PbO + [?] SO_2

[?] PbO + [?] C ⟶ [?] Pb + [?] CO_2

Question 1c (2 marks)

Use the equations above to **outline** why extracting lead from its ore is damaging to the environment.

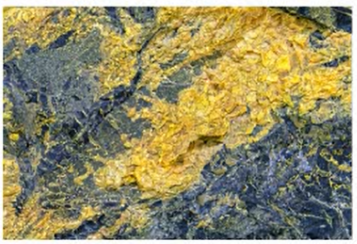
B I U x_2 x^2 Ω Σ Styles

Question 1d (2 marks)

Lead is a metal whilst arsenic is a metalloid.

Lead

Arsenic



©

State two properties of lead as a metal.

Question 1e (2 marks)

Justify whether the properties of lead you gave in part (d) would differ from those of arsenic.

Question 1f (2 marks)

Arsenic has only one stable isotope Arsenic-75. Since 2003, several synthetic isotopes have been identified. **State** the missing values to complete the table.

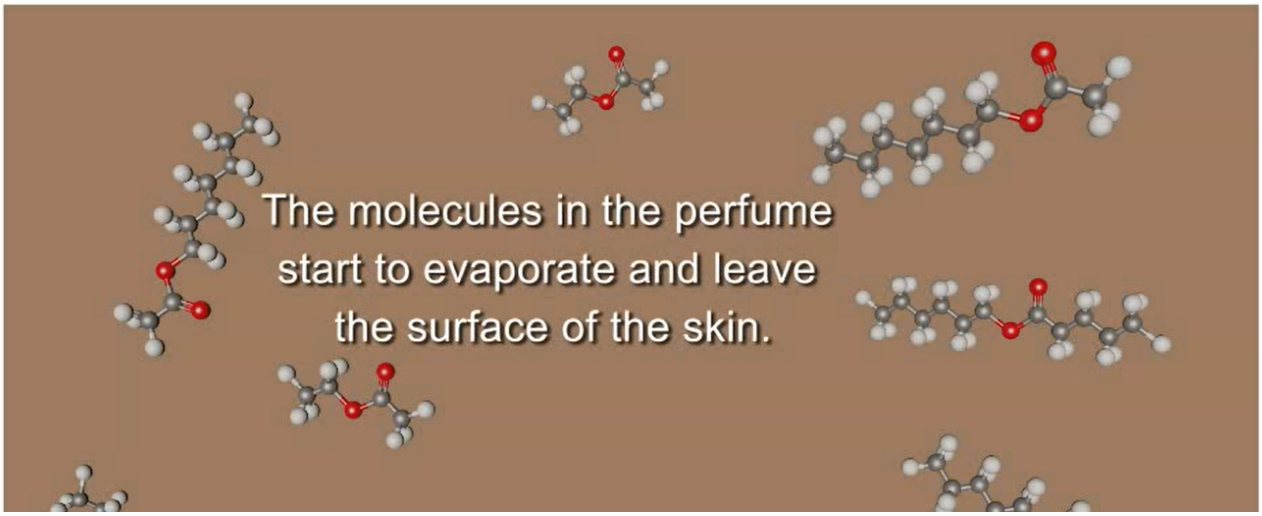
Isotope	Atomic Number	Atomic Mass	Protons	Electrons	Neutrons
^{65}As	33	65		33	32
^{70}As	33	70	33	33	

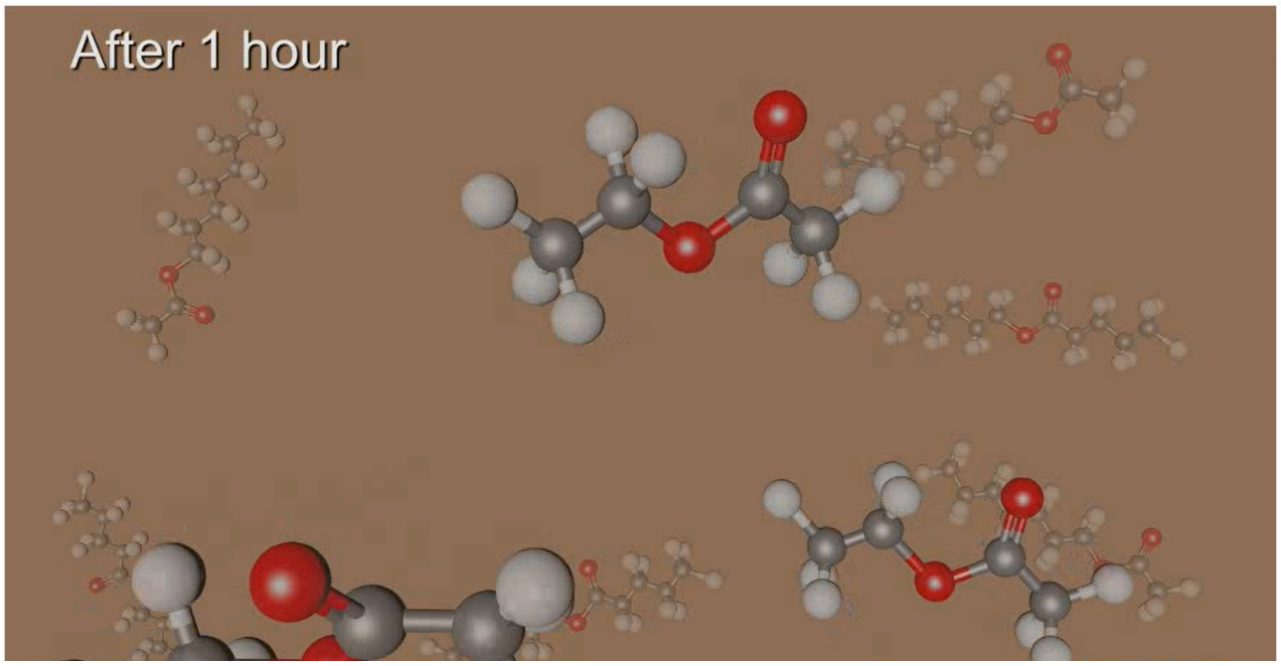
Question 1g (2 marks)

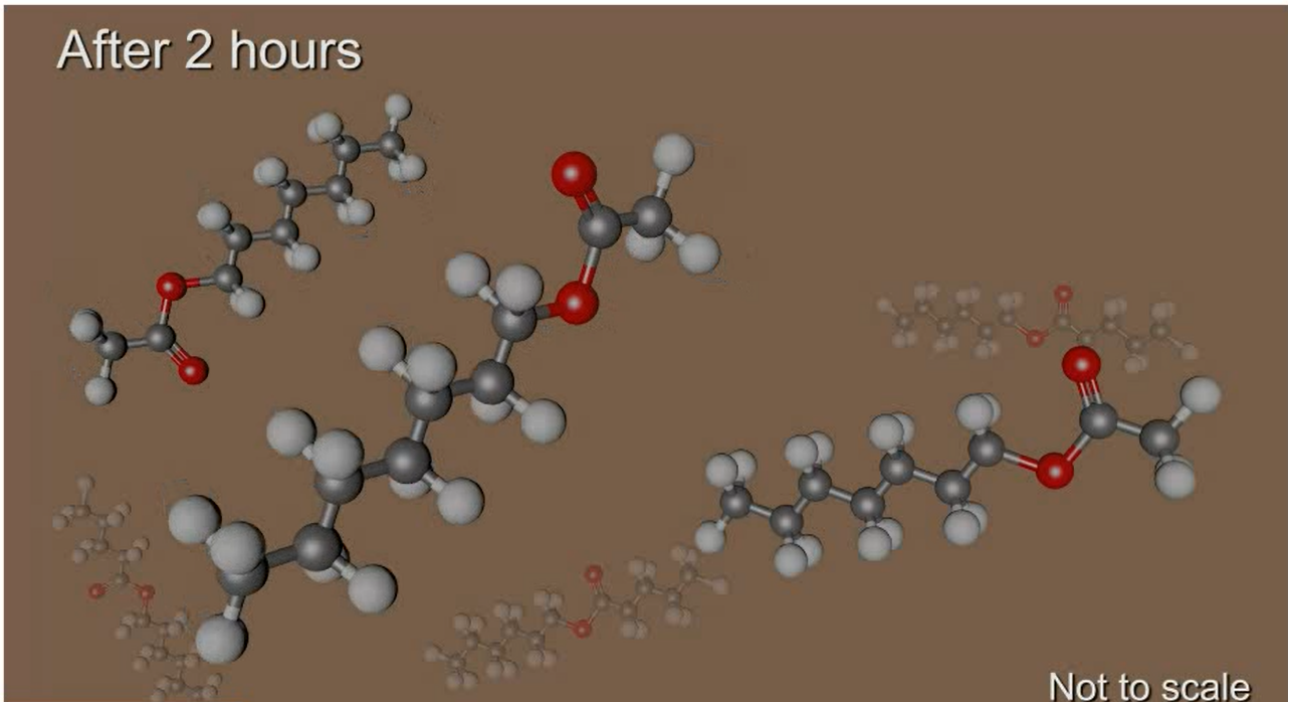
Arsenic reacts with oxygen in the air to form arsenic oxide. **Suggest** whether or not all the isotopes of arsenic react in the same way.

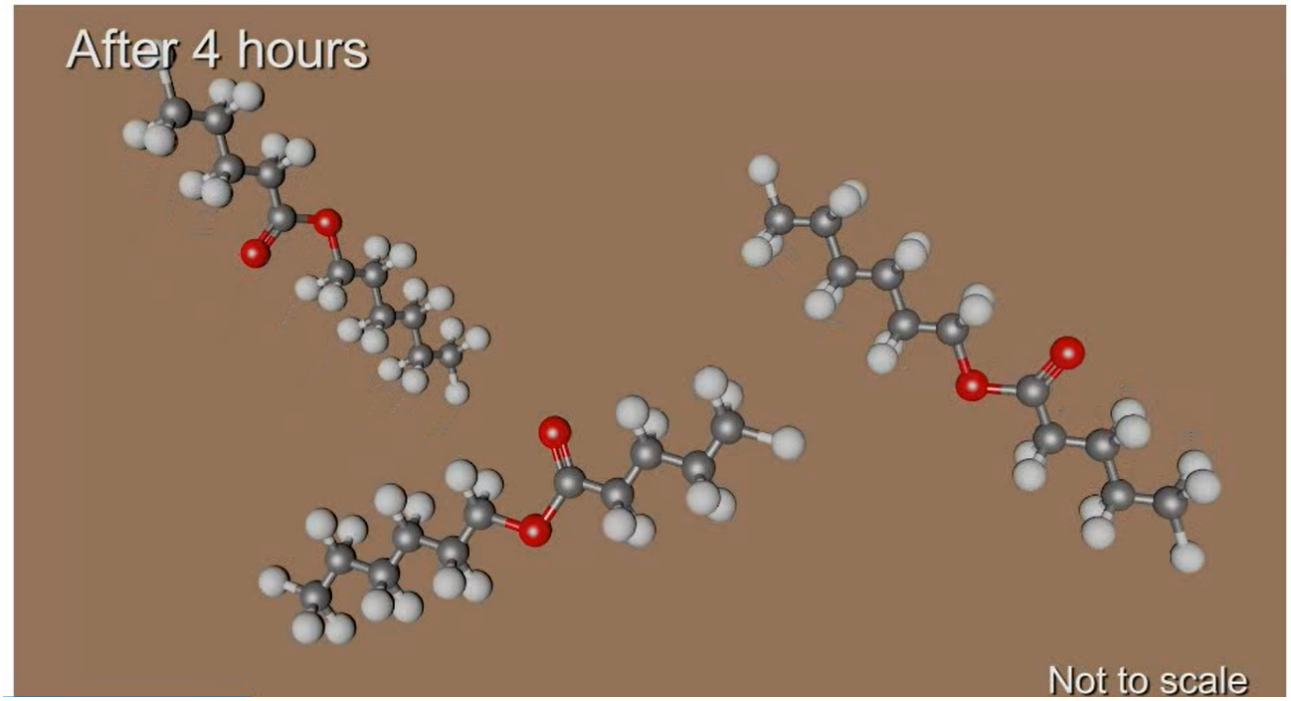
Question 2 (15 marks)

Esters can be classified as volatile organic compounds or VOCs. VOCs are compounds which evaporate easily to become vapours or gases. Esters are described as being volatile substances, in other words, they release vapours easily.



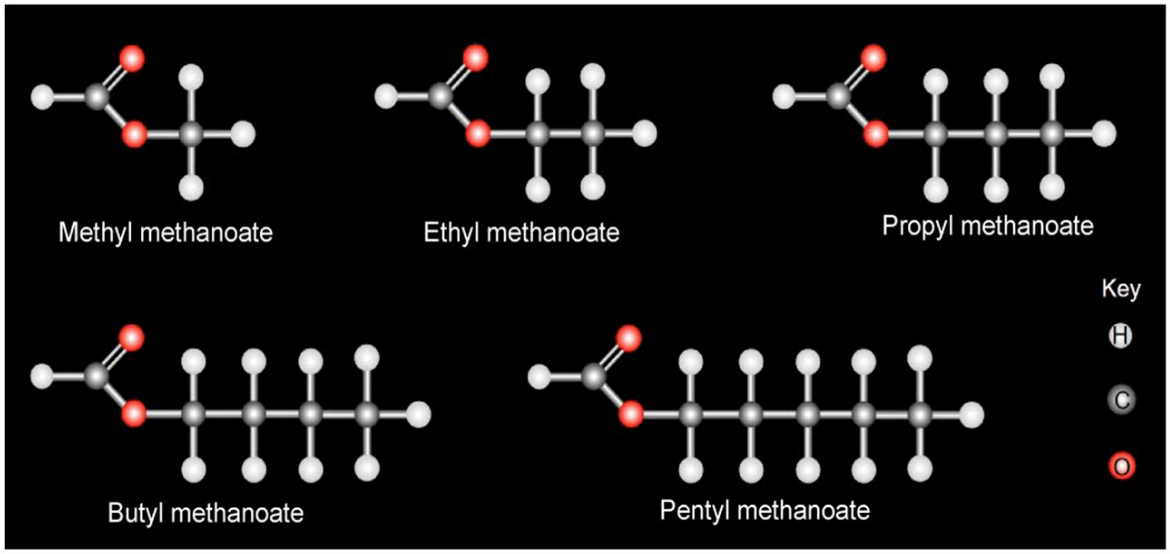



After 2 hours
Not to scale


After 4 hours
Not to scale

All the molecules have left the surface of the skin after approximately 4 hours

Some esters with different volatilities are shown below.



Question 2a (1 mark)

State a research question for an investigation that could test the volatility of these esters.

B I U x_2 x^2 Ω Σ Styles

Question 2b (3 marks)

Formulate a hypothesis for the investigation in part (a).

B I U x_2 x^2 Ω Σ Styles

Question 2c (4 marks)

The volatility of three esters was investigated by measuring the time taken for a sample of the ester to completely evaporate.

Identify the variables in this experiment.

Independent variable:

Question 2d (4 marks)

Perfumes contain complex mixtures of esters. The reaction of alcohol and a carboxylic acid produces an ester.

This is a reversible reaction and after a few days equilibrium is reached. Most reactions producing esters are exothermic.

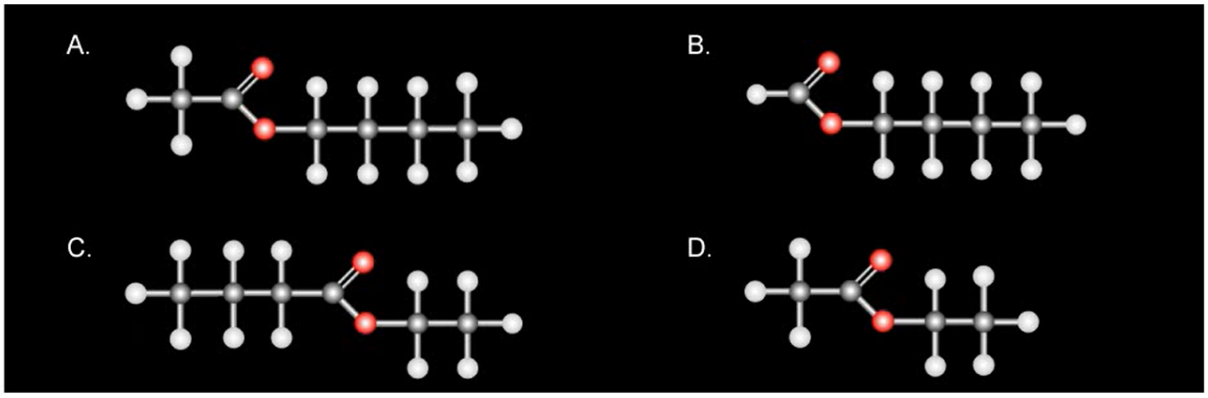
$$\text{alcohol} + \text{carboxylic acid} \rightleftharpoons \text{ester} + \text{water}$$

Using the equation above, **explain** why opened bottles of perfume are ideally stored in cold and dry conditions.

Question 2e (3 marks)

The process of extraction of essential oils is expensive so cosmetics companies add industrially made esters to make their products smell nice. For example butyl ethanoate is added to creams to make them smell like fresh apples.

Select the structural formula of butyl ethanoate and **state** the names of the carboxylic acid and the alcohol that react to form this ester.



Select ▾

Question 3 (28 marks)

Video | Video script

The position of a metal in the reactivity series is related to that metal's ability to displace a different metal from its compound. This can be summarized by the equation:

Metal A + Metal B Compound ⟶ Metal A compound + Metal B.

When 1 mol dm^{-3} copper sulfate solution is added to metal powder a temperature change can be measured.

Question 3a (1 mark)

Copper sulfate is toxic. **Select** the hazard symbol that is used for copper sulfate.

A. 

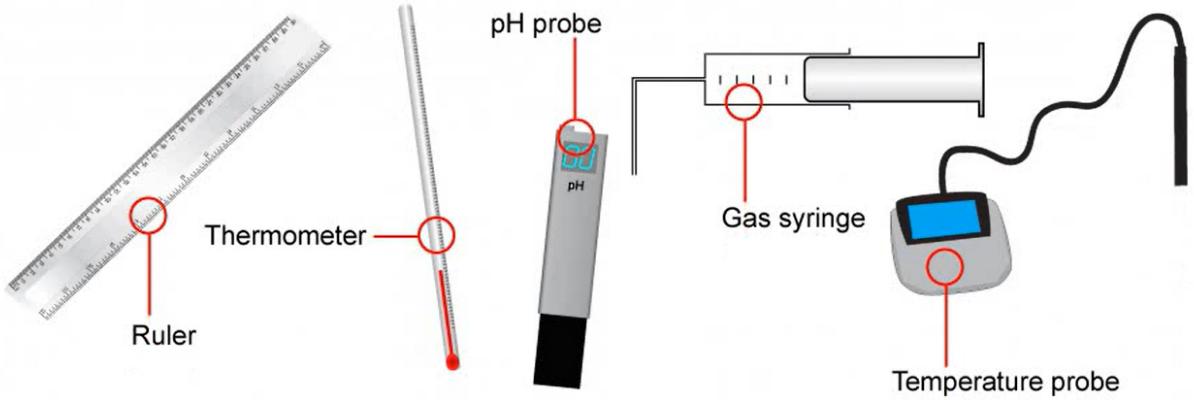
B. 

C. 

D. 

Question 3b (1 mark)

Select one piece of equipment needed to collect appropriate data in this experiment.

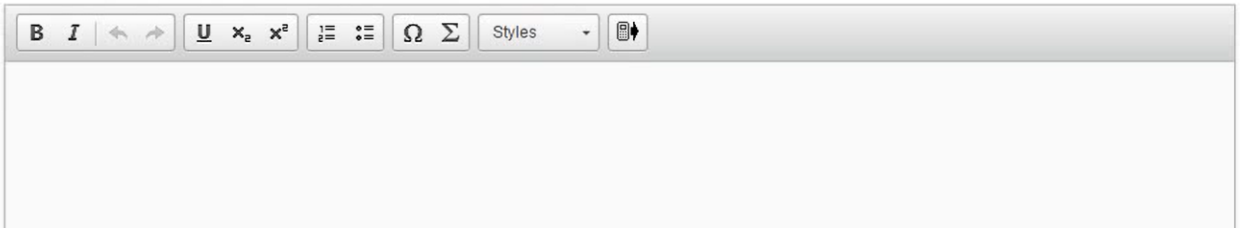


Select

Question 3c (15 marks)

Design a method which would allow you to collect sufficient data to place these metals in order of reactivity. The metals you will use are zinc, iron, magnesium, lead and aluminium. In your answer should include:

- a list of equipment you will use
- the method you will follow
- details of the measurements you will make to collect sufficient, valid data
- how you will make sure your method is safe.



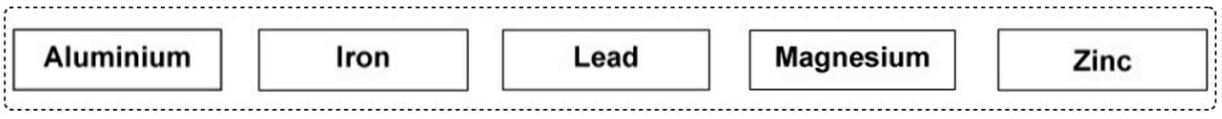
Question 3d (1 mark)

Here are some results from a similar investigation. In this investigation only one set of results was collected.

Metal added	Temperature change for the reaction / °C
Aluminium	39
Iron	16
Lead	12
Magnesium	46
Zinc	32

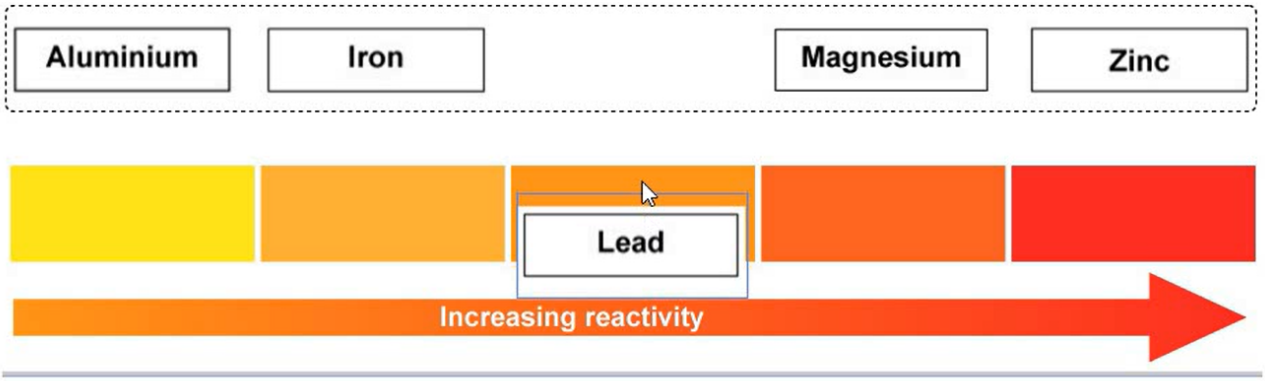
Using the data in the table, **determine** the order of reactivity of these five metals.

Draggable:



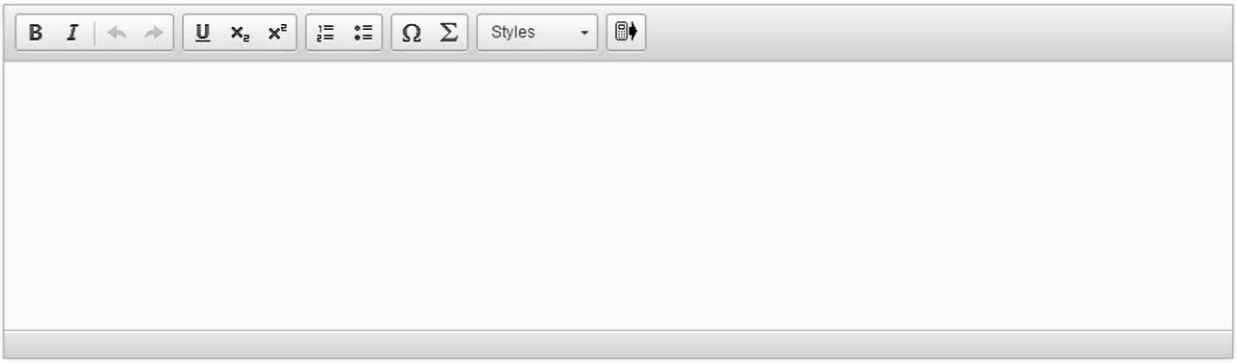
Using the data in the table, **determine** the order of reactivity of these five metals.

Draggable:



Question 3e (2 marks)

Justify your answer using scientific reasoning.



Question 3f (1 mark)

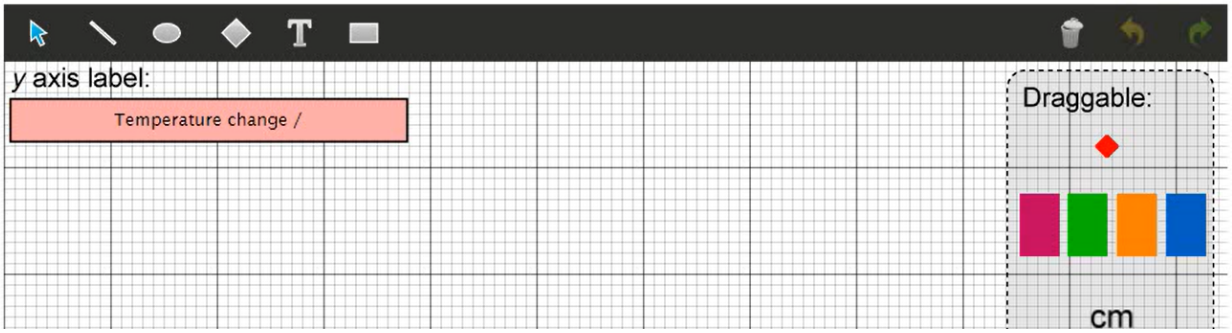
Select the most appropriate graph to present the temperature change data.

Select

Question 3g (5 marks)

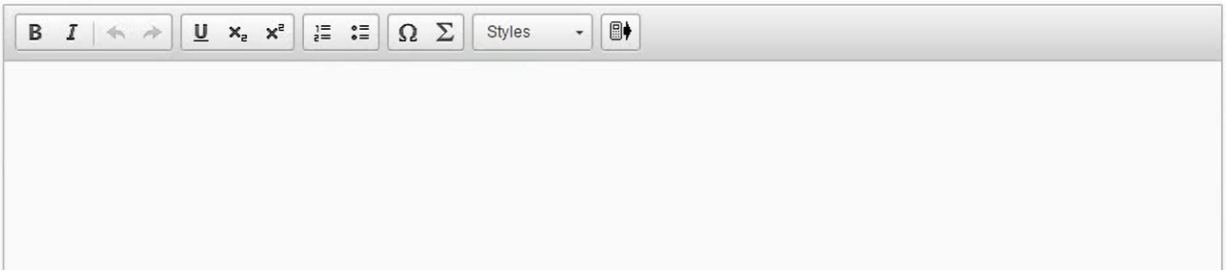
Present the data in the graph. You need to give your graph an appropriate title, **label** the *x* axis and add the correct unit to the *y* axis.

Title:



Question 3h (2 marks)

Comment on the validity of the results in the table and **suggest** an improvement to this investigation.



Question 4 (17 marks)

Coins have been made from metal throughout history. As the availability of the metals changes, the composition of the coins may also have to change. The exact composition of the coin is determined by a number of factors such as lifetime, durability, reaction to the environment and ability to shape the metal.

The composition of the US penny or 1 cent coin has changed in composition a number of times since its introduction in 1793.

Hover over the coins to reveal information, alternatively click "All data".

Year	Composition / %			
	Copper	Nickel	Zinc	Tin
1793 – 1849	100.0	0.0	0.0	0.0
1849 – 1857	95.5	0.0	0.0	5.0
1857 – 1865	88.0	12.0	0.0	0.0
1865 – 1943	95.0	0.0	2.5	2.5
1943 – 1962	100.0	0.0	0.0	0.0
1962 – 1982	95.0	0.0	5.0	0.0
1982 – present	2.5	0.0	97.5	0.0

lata

Question 4a (2 marks)

A scientist has a number of coins and needs to determine when they were made. Unfortunately the dates on the coins are not visible and cannot be read. The scientist has decided that it is possible to determine the age of the coins by reacting them with nitric acid. When the coins are placed in nitric acid a gas is produced. The scientist has suggested that the reaction that takes place is:

$$\text{metal} + \text{nitric acid} \longrightarrow \text{metal nitrate} + \text{hydrogen}$$

State the test for hydrogen gas.

Question 4b (3 marks)

Copper has traditionally been chosen for making coins as this is one of the least reactive, inexpensive metals and it is readily available. Zinc is not normally chosen to make coins as it is more reactive than copper. Zinc is also more reactive than tin.

The scientist has decided that the date of the coin can be determined by measuring the rate of gas production.

Formulate a testable hypothesis about which coin will produce the slowest reaction.

Question 4c (4 marks)

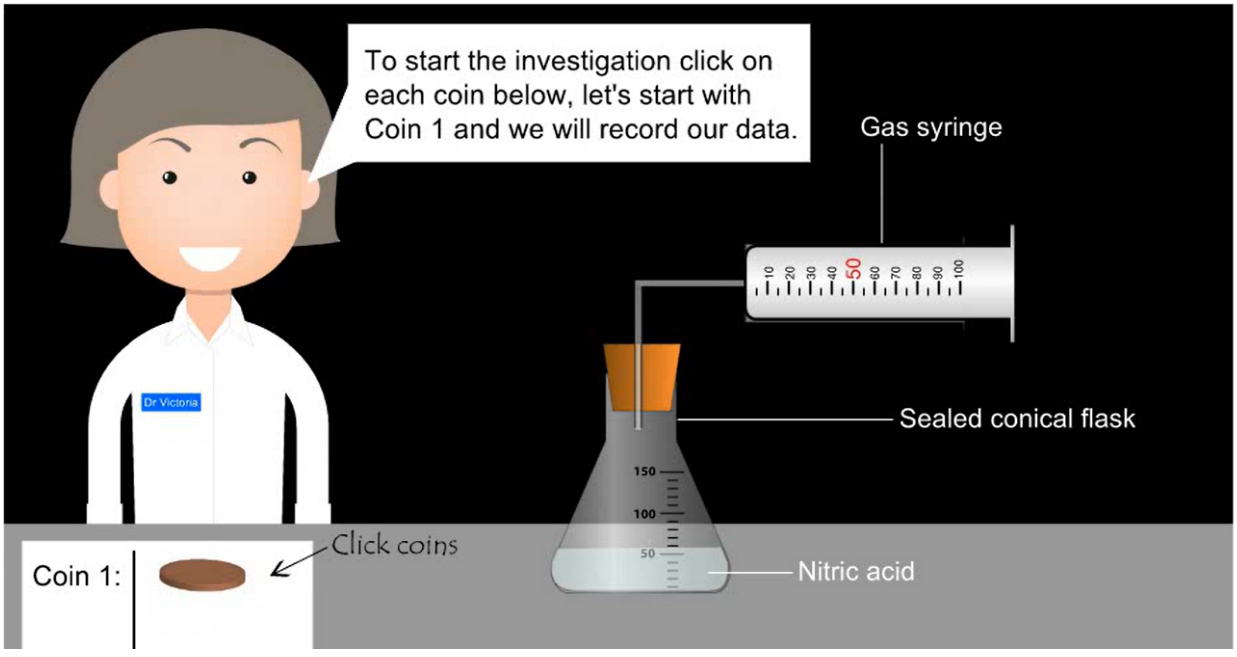
State the independent, dependent and control variables in this investigation.

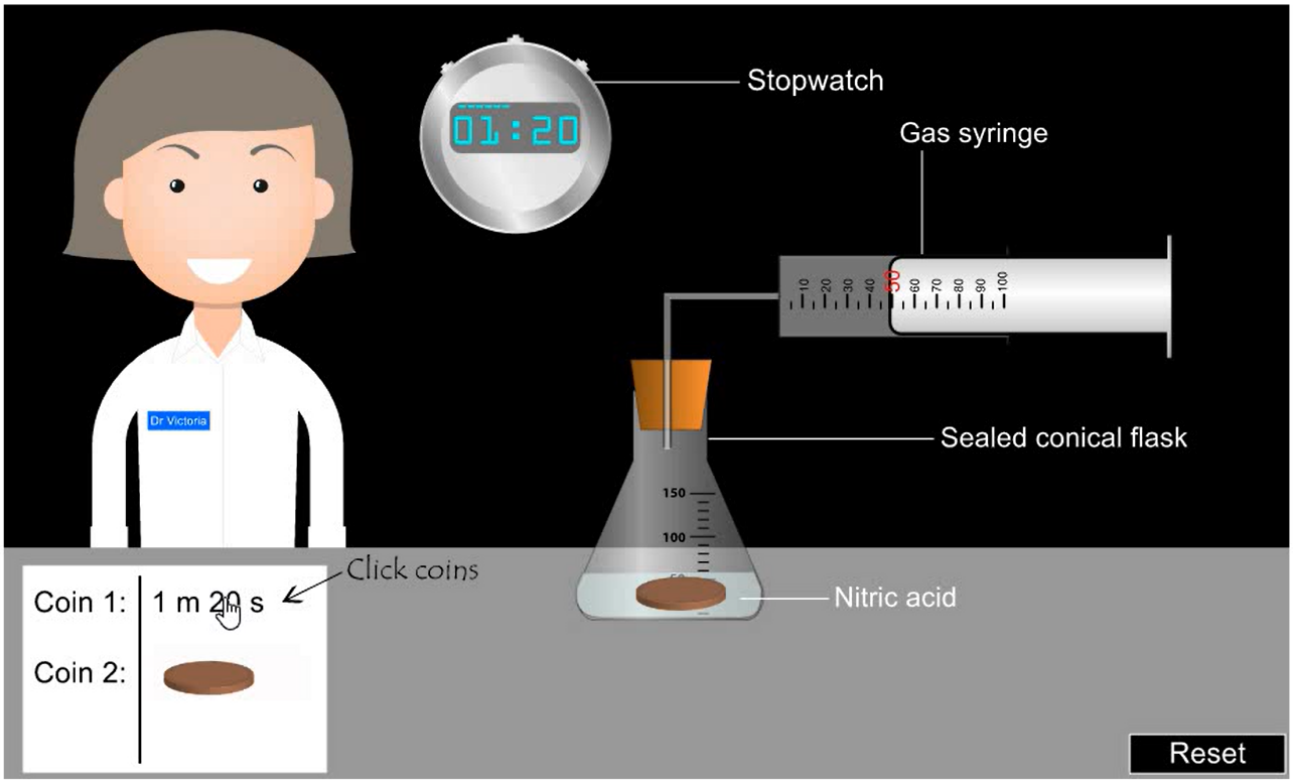
Independent variable:

Question 4d (3 marks)

The simulation shows the investigation being carried out.

This media is interactive

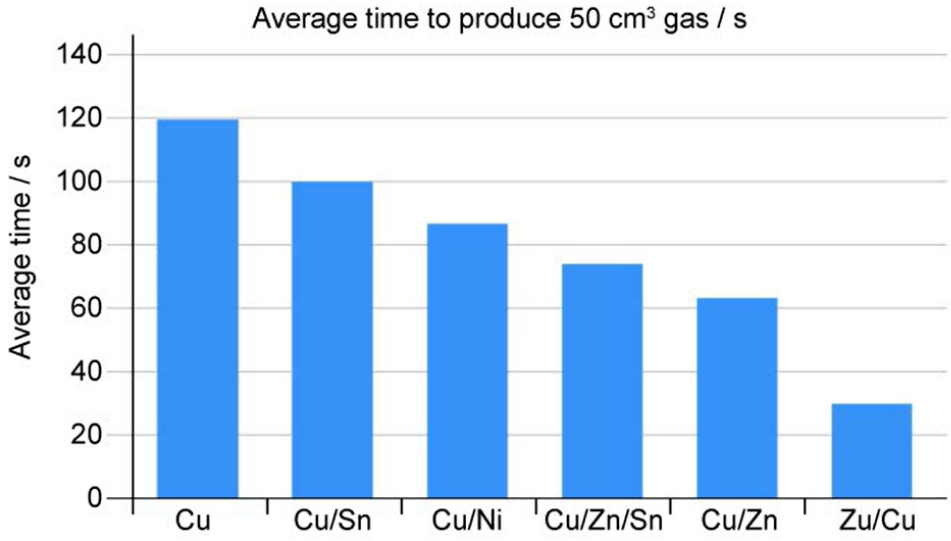




Using the graph below **determine** the year of manufacture of the coins tested.

Coin 1: Select ▾ Coin 2: Select ▾ Coin 3: Select ▾

Graph | Year and composition graph | Experiment data



Question 4e (3 marks)

Discuss why the results that you obtained are not exactly the same as produced in the graph.

B I U x_2 x^2 Ω Σ Styles

Question 4f (2 marks)

Outline the disadvantage of using this method for determining the age of the coins.

B I U x_2 x^2 Ω Σ Styles

Question 5 (11 marks)

Throughout history gold has been used for making masks, jewellery and even coins because it is very unreactive. Gold does not form ores but is mined as pieces of uncombined metal called nuggets. The world's second largest gold nugget is called the Perth Mint nugget. This nugget was kept under a miner's bed for several years before he tried to sell it to the United States. The mass of the nugget is 23218.3 g.

Question 5a (2 marks)

State the mass of the nugget in grams using scientific notation.

Styles

Gold does not react with most acids, however it does react with *aqua regia* (sometimes called "royal water"), which is a mixture of concentrated nitric acid and concentrated hydrochloric acid. *Aqua regia* is used in the touchstone method which can be used used to test the purity of gold. The video below explains how the touchstone method works.

Cultural treasures are sometimes sold on the underground market for profit by illegal traders. This has caused great concern as the treasures are lost and end up in private collections never to be seen again.

A raid was carried out on a suspected illegal trader and a number of golden objects were found. The trader stated that the objects were not real and that they were reproductions. Some of the items found appeared to be historical objects from Egypt, Greece, the United Kingdom and Peru which have been lost for a number of years. The antique gold from each country is shown in the table.

This media is interactive

Question 5b (4 marks)

Gold testing kits contain solutions of *aqua regia* with different concentrations of nitric and hydrochloric acid. Solution A has the highest concentration of *aqua regia* and solution D has the lowest concentration.

A scientist has suggested the following method for determining the gold content of one of the objects using the test solutions listed in the table.

Name	Does a reaction take place?			
Test solutions	24K	18K	14K	10K
Solution A	✓	✓	✓	✓
Solution B		✓	✓	✓
Solution C			✓	✓
Solution D				✓

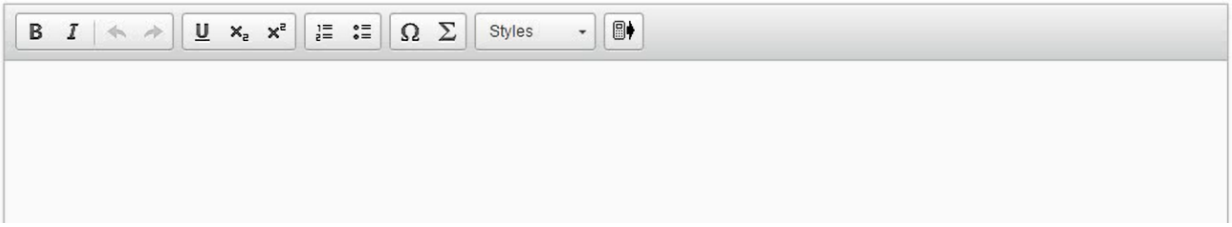
Method

1. Take the object and remove a small piece of gold.
2. Place this piece of gold into a test tube.

Method

1. Take the object and remove a small piece of gold.
2. Place this piece of gold into a test tube.
3. Add 20 cm^3 of solution A into the test tube.
4. Observe and see if the gold dissolves.
5. If the piece of gold dissolves the object is 24K gold.

Discuss the method and **comment** on the validity of the result.



Question 5c (2 marks)

Before the scientist carried out the investigation, they made the following hypothesis:

> The purer the gold, the stronger the *aqua regia* solution will need to be because gold is quick to dissolve.

Use the data in the table to **evaluate** this hypothesis.

Question 5d (2 marks)

A gold sovereign is a coin that has been used as safety money by British military special forces to allow safe passage if caught in conflict. The coin has a mass of 7.89 g and contains 7.322381 g of gold. 24K gold is stated as 100 % gold.

©

State the mass of gold in the gold sovereign coin to 3 significant figures.

Question 5e (1 mark)

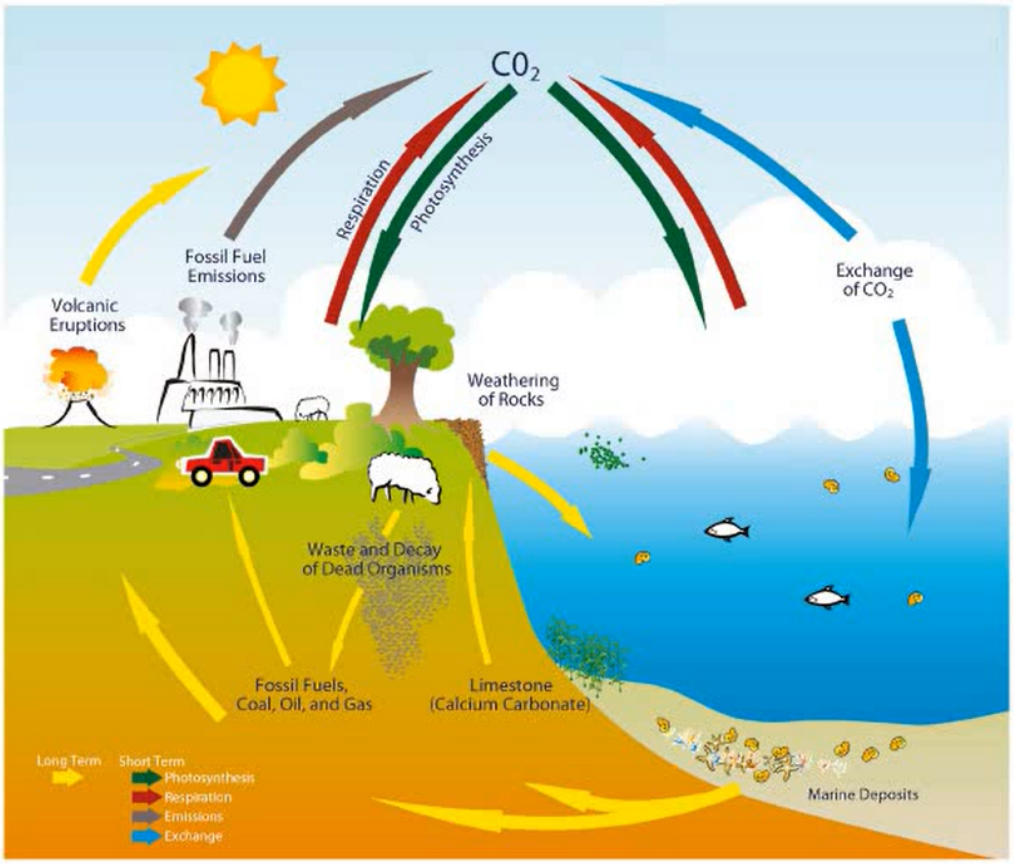
Calculate the percentage of gold contained within the sovereign.

B I U x_2 x^2 Ω Σ Styles

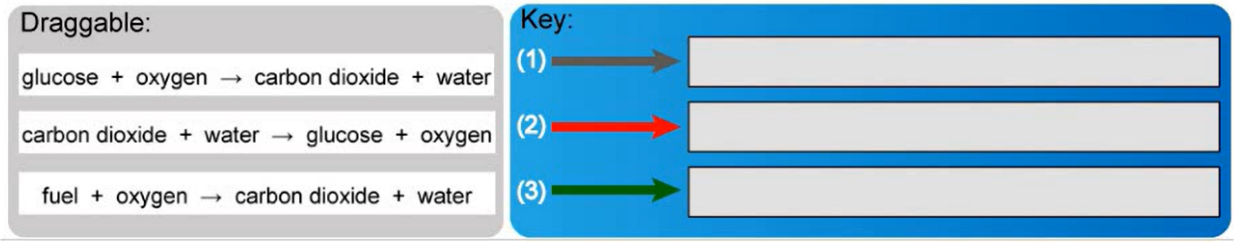
Question 6 (16 marks)

Question 6a (2 marks)

Science has made enormous progress towards understanding climate change and its effects on the Earth's ecosystem. Scientists have strong evidence that recent warming is largely caused by human activities especially the release of greenhouse gases through the burning of fossil fuels.



Label the grey (1), red (2) and green (3) arrows in the key with the correct chemical reactions. Drag each box next to the correct arrow.

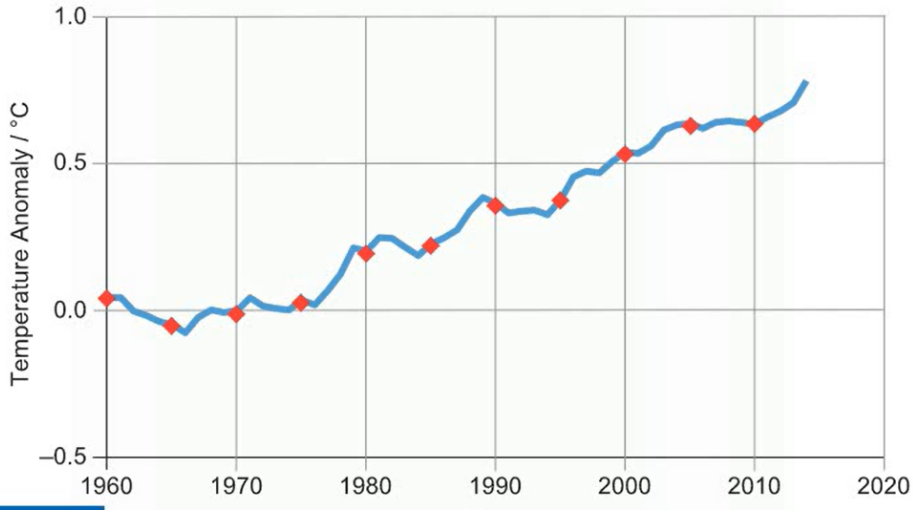


Question 6b (2 marks)

Carbon dioxide (CO_2) is the primary greenhouse gas emitted through human activities. In 2013, CO_2 accounted for about 82 % of all US greenhouse gas emissions from human activities.

This media is interactive

Global Land-Ocean Temperature Index

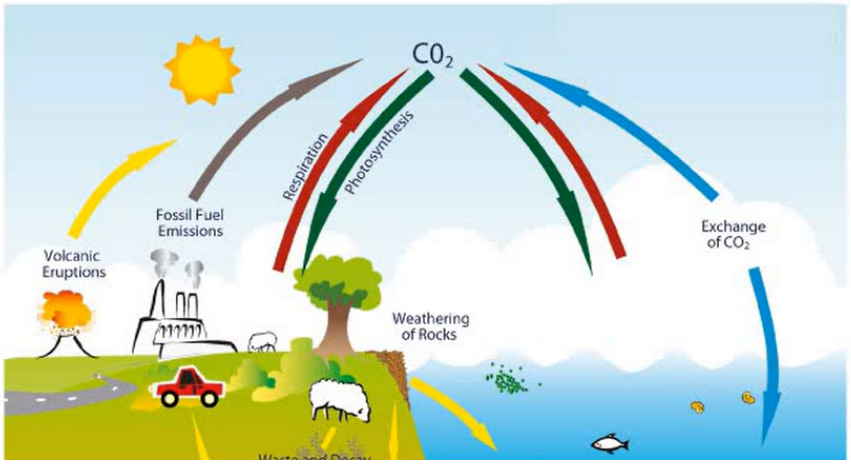


Use the graph to **calculate** the temperature increase from 1980 – 2010.

B I U x_2 x^2 Ω Σ Styles

Question 6c (12 marks)

Human dependence on fossil fuels is altering the natural balance of the carbon cycle. Carb
footprint is the term used to describe the mass of greenhouse gases (carbon dioxide and c
carbon compounds) produced by the consumption of fossil fuels by a particular individual
group.



Question 6c (12 marks)

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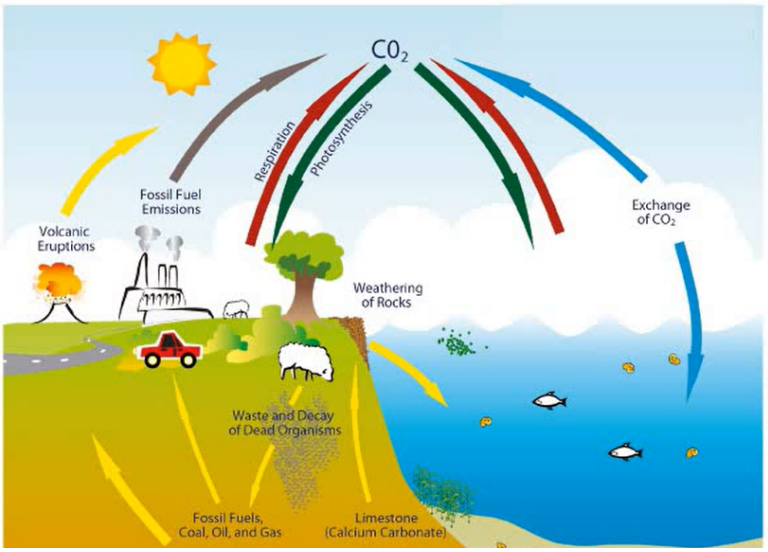
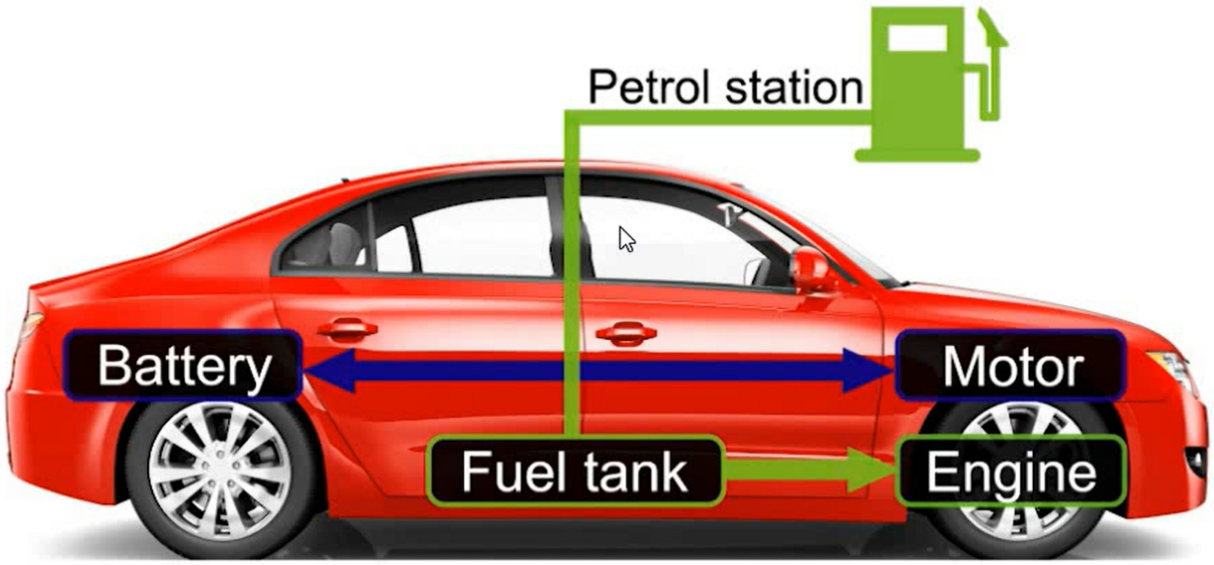


Discuss how society can respond to climate change by altering human behaviour to reduce the carbon footprint. In your answer you should refer to both individuals and larger groups and include:

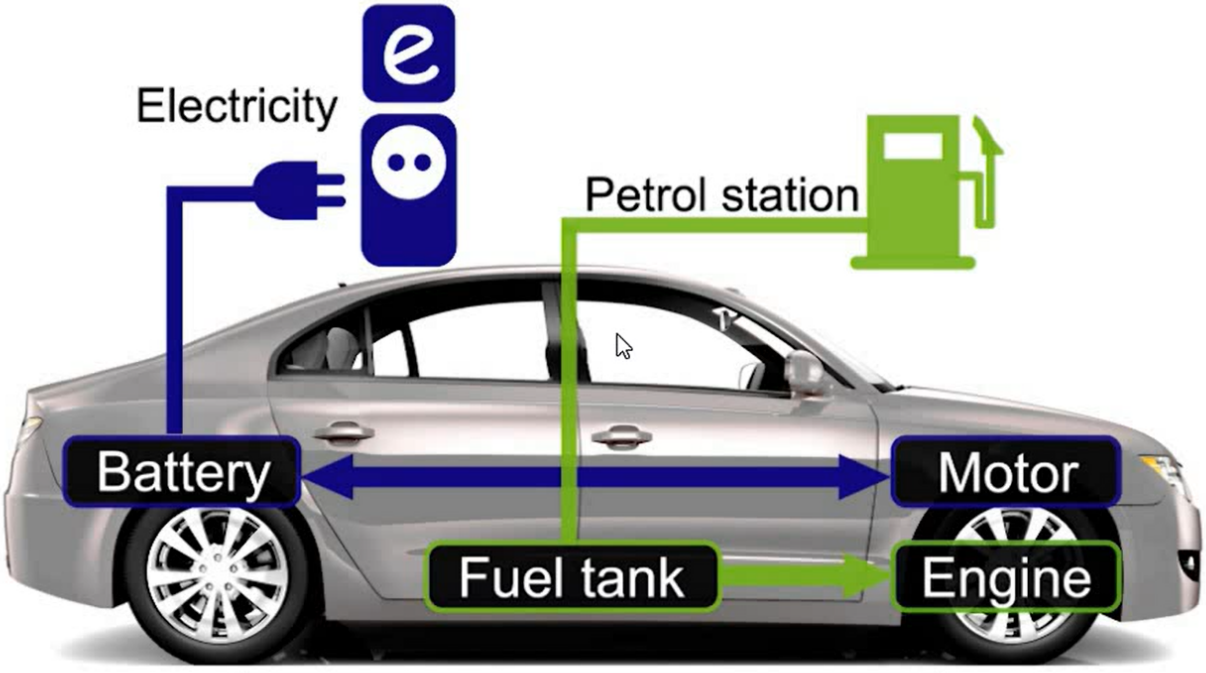
- an outline of activities that increase the carbon footprint
- an explanation of how these activities increase the carbon footprint
- an outline of activities that would decrease the carbon footprint
- a justification of how these activities would affect the carbon cycle.


Environmental sustainability
to reduce the emission of one of the pollutants, carbon dioxide.


Invention of different types of cars
ABB
The car industry has produced electric cars and hybrid cars,

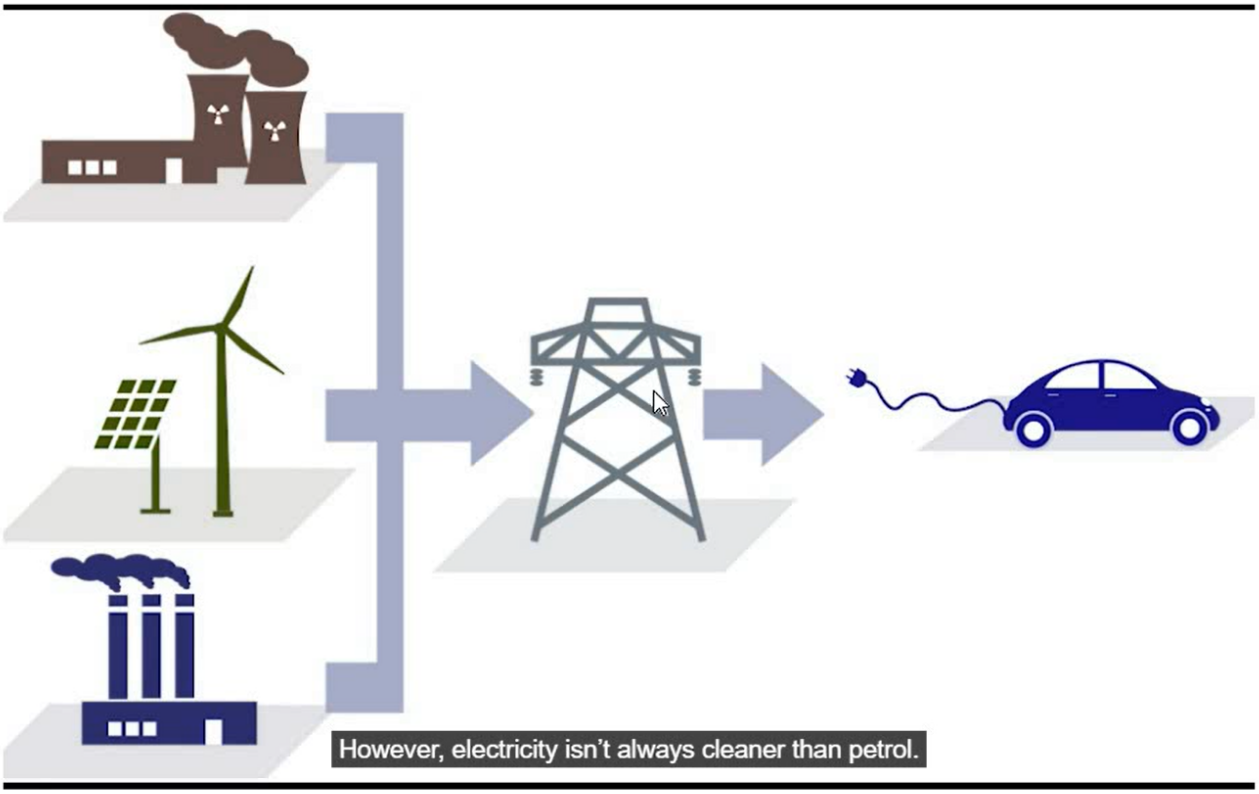


A hybrid car is a cross between a petrol car and an electric car.

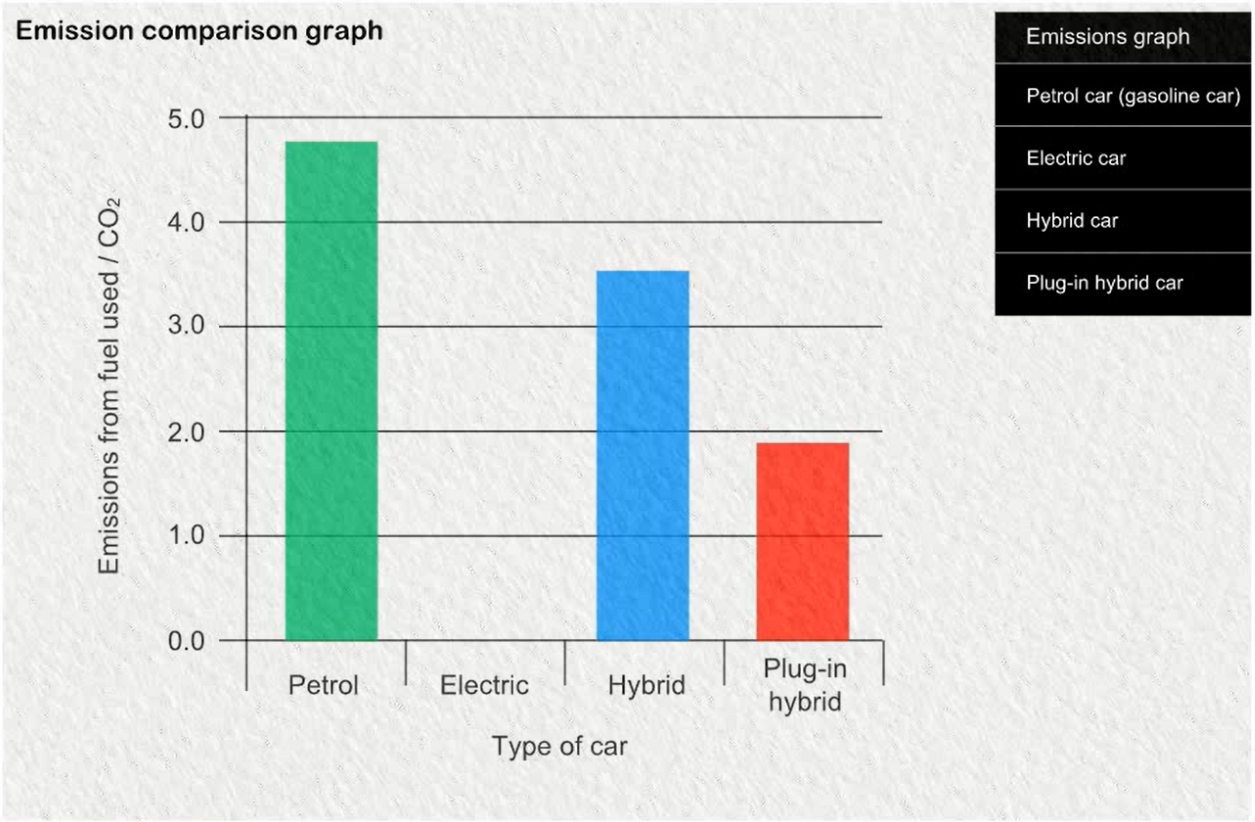


Recently a car manufacturer announced that their scientists


60.00
eco-one
eco


However, electricity isn't always cleaner than petrol.

Emission comparison graph



Select two different types of cars to compare.

Car 1: Select ▾ Car 2: Select ▾

Using all of the information and experience from your wider MYP studies, **discuss** and **evaluate** the impact of driving these cars. In your answer you should consider:

- the environmental impact of the different types of cars you have chosen
- the costs of running the car
- the sustainability of the fuel
- the usefulness of the cars.