Top of the Bench 2023
Younger Paper

Name:

School:

School year:

Answer all questions in the spaces provided.

You are provided with a Periodic table.

Write your answers clearly. Show all working.

Section A contains questions about general chemical knowledge.

Section B contains questions about this year's theme: Sustainable energy

The total marks allocated to the paper are 40 marks (Section A 10 marks, Section B 30 marks)

The time allocated to the paper is 40 minutes.

Question	Mark
Section A	
9	
10	
11	
TOTAL	

SECTION A General chemistry knowledge

1. Name the element used as a disinfectant in swimming pools. _____ [1]

2. Name an element that is a liquid at room temperature. _____ [1]

3. This question is about the reaction between sulfuric acid and copper oxide.

The equation for the reaction is:

$$H_2SO_4(aq) + CuO(s) \rightarrow CuSO_4(aq) + H_2O(l)$$

a. What does the symbol (aq) mean? [1]

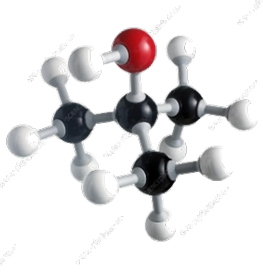
_____

b. What is the type of reaction between sulfuric acid and copper oxide?
Circle **one** word. [1]

displacement **neutralisation** **precipitation**

4. Give the molecular formula of the molecule shown in **Figure 1**. _____ [1]

Figure 1



Black = carbon

White = hydrogen

Red = oxygen

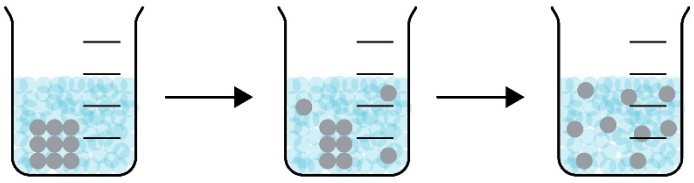
5. Name the **gas** produced when the two chemicals given react; [2]

a. magnesium + hydrochloric acid _____

b. sodium carbonate + hydrochloric acid _____

6. Identify the process represented in **Figure 2**. _____ [1]

Figure 2



7. 100 g of calcium carbonate undergoes thermal decomposition to produce 56 g of calcium oxide.

The equation for the reaction is $CaCO_3 \rightarrow CaO + CO_2$.

Calculate the mass of carbon dioxide produced. _____ g [1]

8. Balance the symbol equation: __ $Fe(OH)_3$ → __ Fe_2O_3 + __ H_2O [1]

Turn over for Section B

SECTION B Questions linked to this year's theme of Sustainable Energy

9. This question is about the origin of the UK's energy supply.

The UK obtains its energy from a mixture of fossil fuels and other energy sources including sustainable sources.

An energy source can be described as sustainable if its use today does not impact negatively on the lives of people in the future.

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The data in **Table 1** shows the sources of energy supplied to the UK on a day in October 2022.

Table 1

		Energy in Gigawatts, GW
Fossil fuels	Coal	0
	Oil	0
	Gas	13.0
Sustainable sources	Solar photovoltaic	0.5
	Wind	15.5
	Hydroelectric	0.5
Other sources	Nuclear	4.5
	Biomass	0.5
	Other	0.2
	TOTAL	**34.90**

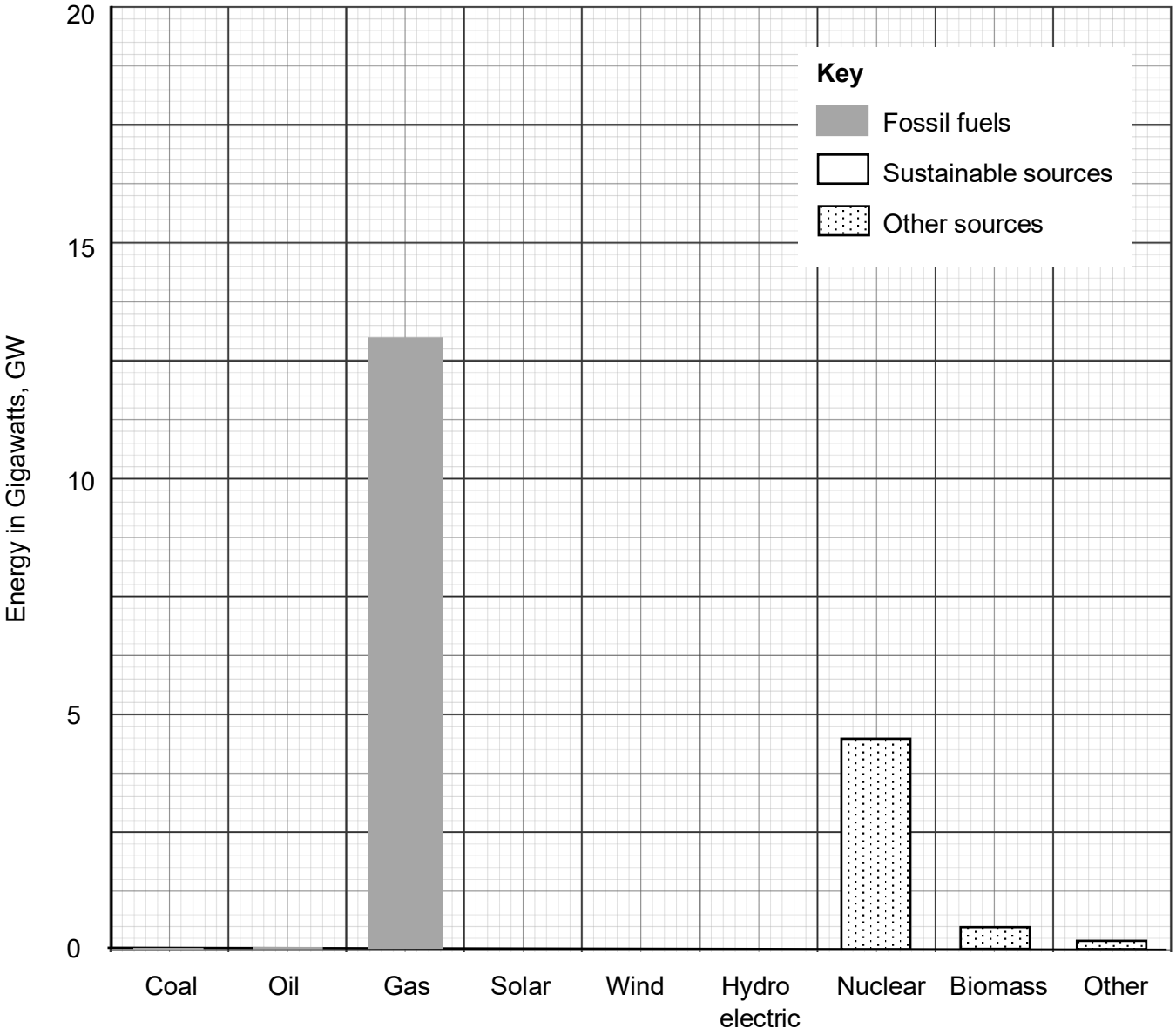
Data taken from https://grid.iamkate.com/

The question continues on the next page

a. Complete the bar chart in **Figure 3**.

Add bars for each of the sustainable sources. [3]

Figure 3



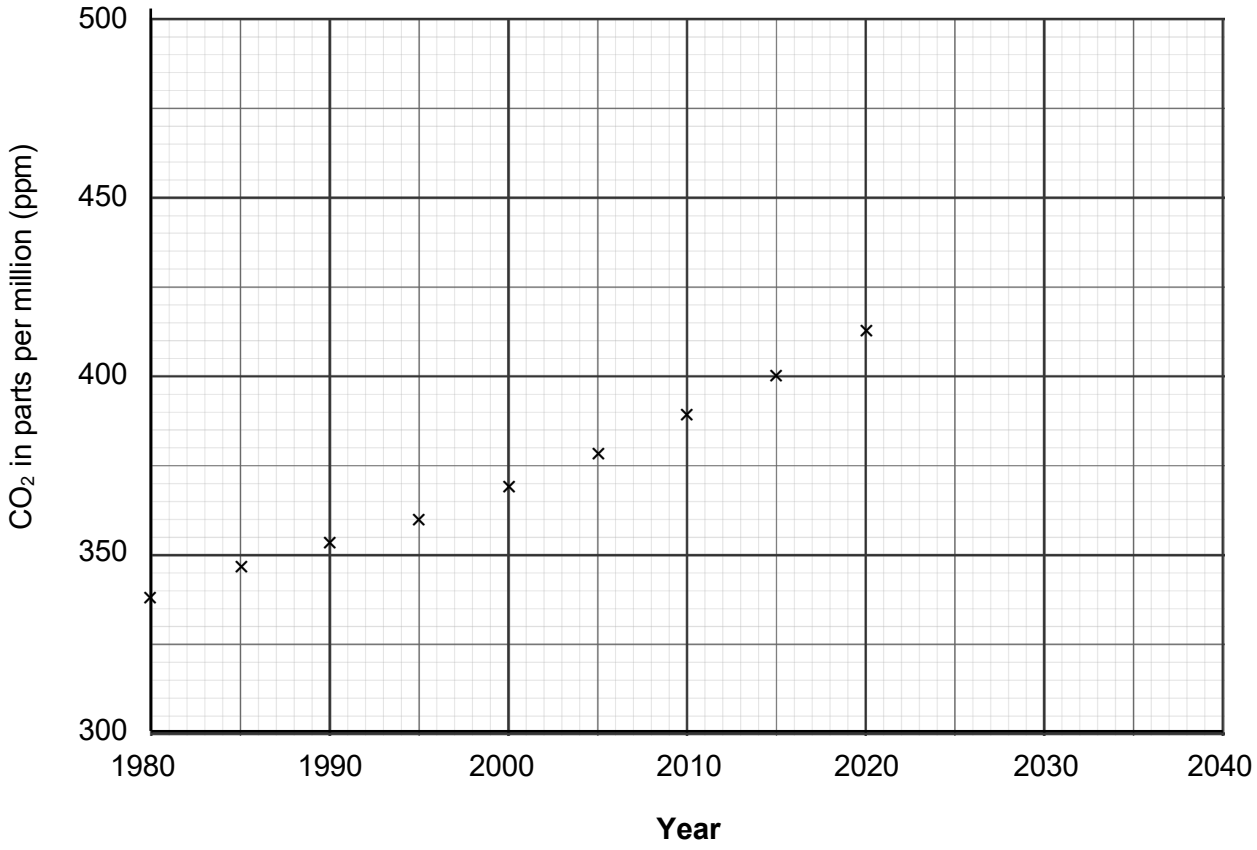
b. Which sustainable source provided the **most** energy? [1]

_____

c. One reason why fossil fuels are non-sustainable is because they release carbon dioxide when they undergo complete combustion.

Figure 4 shows how the amount of carbon dioxide in the atmosphere has changed since 1980.

Figure 4



i. Draw a smooth **curve** of best fit through the points. [1]

ii. Extend your curve of best fit to 2040.

Predict the level of CO_2 in ppm in 2035 if the levels continue to rise in a similar way. [2]

_____

The temperature of the Earth is increasing.

Increasing temperatures are caused by the increased levels of carbon dioxide in the atmosphere.

d. Give **two** impacts of increased global temperatures. [2]

1. _____

_____

2. _____

_____

[Total: 9 marks]

10. This question is about energy storage.

Many sustainable sources of energy such as wind turbines and solar panels only generate power if the wind is blowing or the sun is shining.

The ability to store generated energy so that the energy can be used when needed is important.

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This question is about different methods scientists have developed for storing energy.

One way to store energy is in **rechargeable batteries**.

a. The most common rechargeable batteries contain lithium.

Lithium is a group one metal.

i. Give the chemical symbols of **two other** metals in group one. [1]

_____

ii. Group one metals react with water to produce the metal hydroxide and hydrogen.

Write a **word** equation for the reaction of lithium with water. [1]

_____

_____

iii. Group 1 metals become more reactive down the group.

A student reacts small pieces of lithium, sodium and potassium with water.

Describe **one** observation the student makes that shows potassium is the **most reactive** of the three metals. [1]

_____

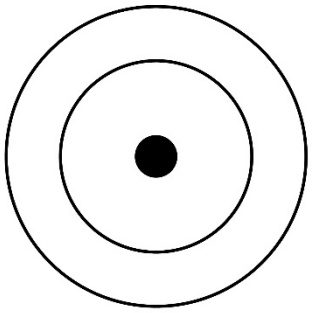
_____

_____

b. When the battery is used to power a device the lithium atoms are converted into lithium ions.

i. Complete **Figure 5** to show the electronic structure of a lithium **atom**. [1]

Figure 5



ii. Predict the charge on the lithium ion formed. [1]

_____

An alternative method of energy storage system is to use **hydrogen**.

The energy generated from the sustainable sources is initially used to electrolyse water.

During **electrolysis** water is broken down into hydrogen and oxygen using electricity.

c. Write a balanced **symbol** equation for the electrolysis of water. [2]

_____

The hydrogen produced by electrolysis is then stored and used as a fuel when needed.

Scientists are developing cars that use hydrogen gas as fuel.

One challenge scientists face is to find a way to safely store the hydrogen.

Compressing hydrogen gas allows hydrogen to be stored more easily.

d. i. At room temperature and pressure 1 kg of hydrogen occupies a volume of 12 m^3.
Calculate the density of hydrogen gas in kg / m^3 under these conditions. [1]

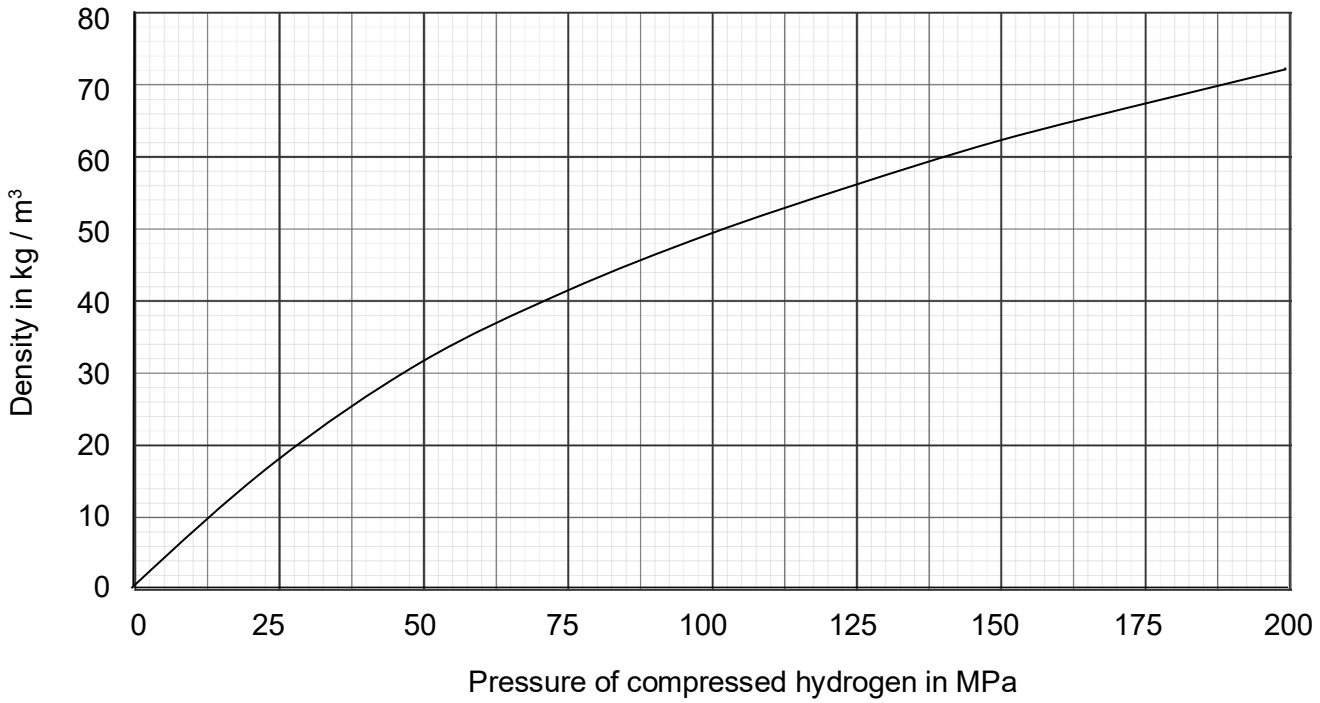
_____

_____

Density _____ kg / m^3

Figure 6 shows how the density of hydrogen changes with pressure.

Figure 6



ii. Describe the trend shown in **Figure 6**. [1]

_____

_____

iii. A car fuel tank has a volume of 125 litres.

A full fuel tank can contain 5 kg of hydrogen.

Determine the pressure the hydrogen is stored at in the fuel tank.

Use **Figure 6**.

1000 litre = 1 m^3 [3]

_____

_____

_____

_____

[Total: 12 marks]

11. This question is about Biogas.

Biogas is a renewable fuel produced by the breakdown of organic matter such as food scraps and animal waste.

Biogas consists mainly of the gases methane, CH_4, and carbon dioxide, CO_2.

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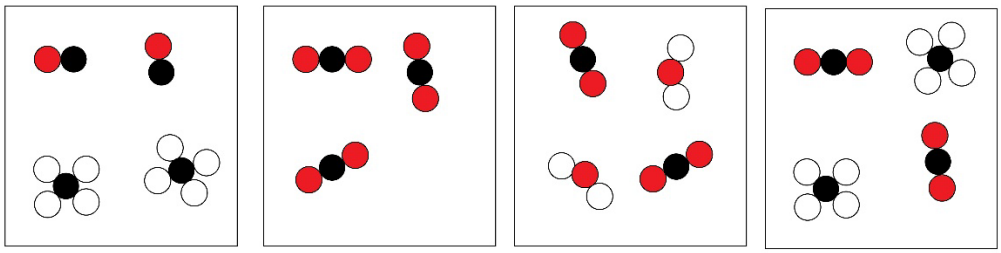
a. i. Methane is a **hydrocarbon**. What is a hydrocarbon? [1]

_____

_____

ii. Select the image that **best** represents biogas.

Tick **one** box. [1]



b. Explain why biogas is described as **renewable**. [1]

_____

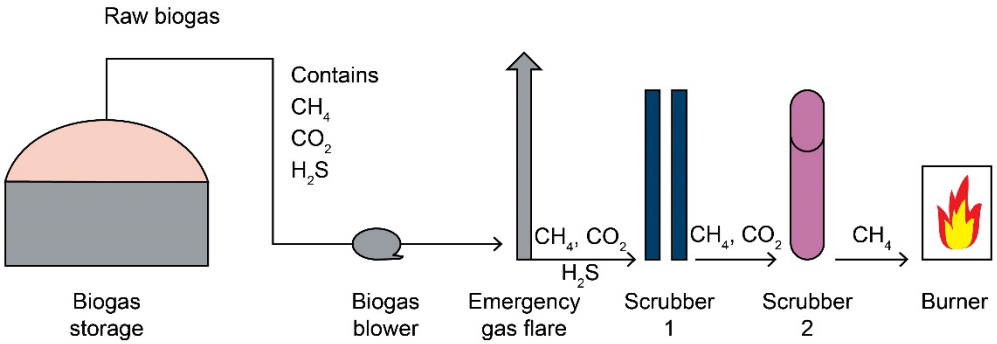
_____

Biogas may also contain small quantities of other impurities.

Biogas must be purified before use.

Figure 7 shows the steps involved in the purification process.

Figure 7



c. i. Give the formula of the impurity removed by **Scrubber 1**. [1]

_____

ii. **Scrubber 2** removes the carbon dioxide impurities.

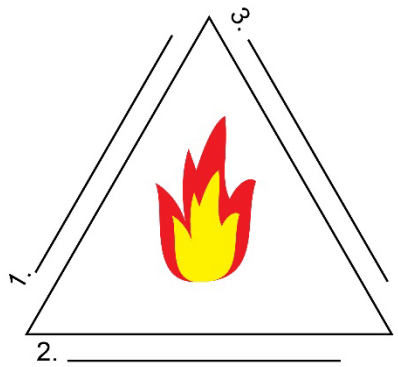
The carbon dioxide reacts with a solution of sodium hydroxide to form sodium carbonate.

What is the pH of a sodium hydroxide solution? [1]

_____

Once purified the biogas produced can be used as a fuel.

d. i. Complete the fire triangle to show the three factors needed for a fire. [1]



ii. Write a word equation for the **complete combustion** of methane. [1]

_____

_____

iii. In a limited supply of oxygen, methane will react by **incomplete combustion**.

A toxic gas is produced.

Name the toxic gas. [1]

_____

e. The torch at the 2008 Beijing Olympics was fuelled by methane produced from biogas.

It used 6000 m^3 of methane per hour and was kept alight for 16 days.

Calculate the total volume of methane burnt during the Beijing Olympics. [1]

_____

_____

[Total: 9 marks]