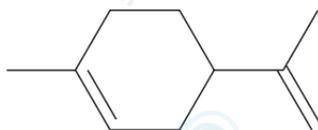


3 This question is about limonene.



(a) What is the molecular formula of limonene?

(1)

A  $C_{10}H_{10}$

B  $C_{10}H_{16}$

C  $C_{10}H_{18}$

D  $C_{10}H_{22}$

(b) Limonene is completely hydrogenated by hydrogen in the presence of a nickel catalyst. What is the **empirical formula** of the product formed?

(1)

A  $C_5H_{11}$

B  $C_5H_9$

C  $C_5H_8$

D  $CH_2$

(Total for Question 3 = 2 marks)

5 This question is about the production of ethanol by fermentation of glucose or by hydration of ethene.

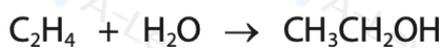
(a) What is the percentage atom economy by mass for the production by fermentation?



(1)

- A 24.4%
- B 25.6%
- C 48.9%
- D 51.1%

(b) What is the percentage atom economy by mass for the production by hydration?



(1)

- A 39.1%
- B 60.9%
- C 78.2%
- D 100%

**(Total for Question 5 = 2 marks)**

3 The formula of calcium carbide is  $\text{CaC}_2$ .

(a) What is the formula of the carbide ion?

(1)

- A  $\text{C}_2^-$
- B  $\text{C}_2^+$
- C  $\text{C}_2^{2-}$
- D  $\text{C}_2^{2+}$

(b) Excess calcium carbide and 10 g of water react to form the hydrocarbon ethyne,  $\text{C}_2\text{H}_2$ .



What is the mass of ethyne that forms, assuming a yield of 100%?

[ $M_r$  values:  $\text{H}_2\text{O} = 18.0$   $\text{C}_2\text{H}_2 = 26.0$ ]

(1)

- A 7.22 g
- B 14.4 g
- C 23.4 g
- D 28.9 g

(Total for Question 3 = 2 marks)

4 Two identical sealed flasks, containing different gases, are side by side. Each flask contains one gas, with the gases at the same temperature and pressure.

Flask **A** contains  $4.0 \times 10^{-3}$  mol of methane.

Flask **B** contains 160 mg of a different gas.

Which could be the gas in Flask **B**?

- A argon
- B carbon dioxide
- C helium
- D neon

(Total for Question 4 = 1 mark)

7 Calculate the mass of sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) required to make up  $250\text{ cm}^3$  of a  $0.100\text{ mol dm}^{-3}$  solution.

[ $A_r$  values: C = 12.0 O = 16.0 Na = 23.0]

- A 1.30 g
- B 2.65 g
- C 5.30 g
- D 10.6 g

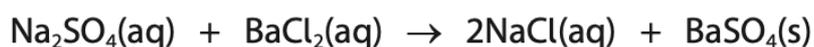
**(Total for Question 7 = 1 mark)**

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10 An excess of sodium sulfate solution is added to  $50\text{ cm}^3$  of a  $0.100\text{ mol dm}^{-3}$  solution of barium chloride.

What is the mass of barium sulfate formed?

[ $M_r$  value:  $\text{BaSO}_4 = 233.4$ ]



- A 1.167 g
- B 2.334 g
- C 11.67 g
- D 23.34 g

**(Total for Question 10 = 1 mark)**

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**17** Sodium hydroxide can be obtained as a hydrate,  $\text{NaOH}\cdot x\text{H}_2\text{O}$ . When heated, the water of crystallisation is lost, leaving anhydrous sodium hydroxide,  $\text{NaOH}$ , as shown in the equation.



An experiment was carried out to determine the value of  $x$  in  $\text{NaOH}\cdot x\text{H}_2\text{O}$ .

### Procedure

**Step 1** Weigh and record the mass of a clean, dry crucible.

**Step 2** Add approximately 1.0 g of  $\text{NaOH}\cdot x\text{H}_2\text{O}$  to the crucible and record the mass.

**Step 3** Heat the crucible and its contents until a constant mass has been reached.

**Step 4** After allowing to cool, reweigh the crucible and the anhydrous solid.

**Step 5** Calculate and record the mass of the anhydrous solid.

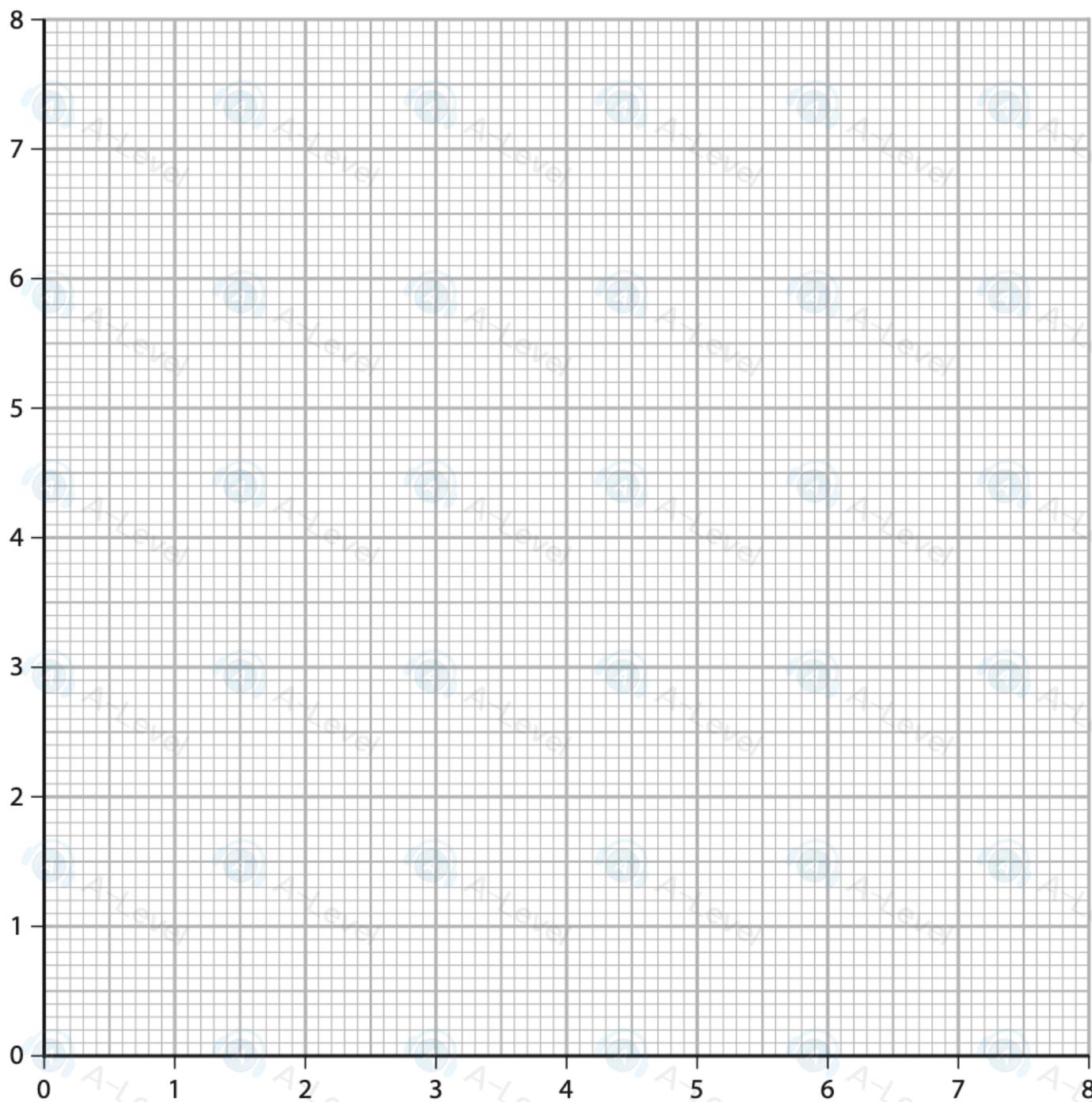
Repeat Steps **1** to **5** using a different mass of the hydrated sodium hydroxide.

### Results

Mass of $\text{NaOH}\cdot x\text{H}_2\text{O}$ / g	Mass of $\text{NaOH}$ / g
1.00	0.69
2.10	1.45
3.50	2.41
4.90	3.38
6.60	4.55
8.00	5.52

- (a) (i) Complete a graph of the results by
- plotting the points
  - labelling the axes
  - including a straight line of best fit.

(3)



- (ii) Use your graph to determine the mass of  $\text{NaOH}\cdot x\text{H}_2\text{O}$  needed to form 4.0 g of  $\text{NaOH}$ . You must show your working on the graph.

(1)

- (iii) Calculate the value of  $x$  in  $\text{NaOH}\cdot x\text{H}_2\text{O}$  using your answer to (a)(ii) and the equation for the reaction.



(3)

- (b) Sodium hydroxide also forms a heptahydrate,  $\text{NaOH}\cdot 7\text{H}_2\text{O}$ .

Calculate the mass of this heptahydrate needed to make  $250\text{ cm}^3$  of a solution of sodium hydroxide of concentration  $0.150\text{ mol dm}^{-3}$ .

(2)

**20:** This question is about carbon dioxide.

- (a) According to data from 2021, there are 415 ppm of carbon dioxide in the atmosphere by volume.

Calculate the moles of carbon dioxide present in  $1.00\text{ m}^3$  of air at  $20.0^\circ\text{C}$  and  $101\text{ kPa}$ .

$$\begin{aligned} &[\text{Ideal gas equation } pV = nRT \\ &R = 8.31\text{ J mol}^{-1}\text{ K}^{-1}] \end{aligned}$$

(4)

(b) Dodecane  $C_{12}H_{26}$ , is found in kerosene and forms carbon dioxide during its complete combustion.

(i) State what is meant by complete combustion.

(1)

(ii) Write a balanced equation for the complete combustion of dodecane,  $C_{12}H_{26}$ .

Include state symbols.

(2)

(iii) Kerosene is used as aeroplane fuel. A jet plane can carry a maximum of 800 passengers and uses  $11\,400\text{ dm}^3$  of fuel per hour.

Calculate the mass, in kg, of carbon dioxide emitted from the engine per passenger on a full flight from Sydney to Hong Kong, flight time 9 hours 15 minutes.

Give your answer to three significant figures.

[Assume kerosene consists solely of  $C_{12}H_{26}$

Density of dodecane =  $0.749\text{ g cm}^{-3}$ ]

(6)

(iv) The formula  $C_{12}H_{26}$  represents many isomers, including six diethyloctanes. The names of four of these diethyloctanes are

3,3-diethyloctane, 3,4-diethyloctane, 3,5-diethyloctane,  
3,6-diethyloctane.

Draw the **skeletal** formulae of the remaining two diethyloctanes.

(2)



(Total for Question 20 = 15 marks)