

Energetics

9 questions · 74 marks

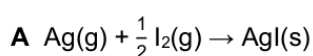
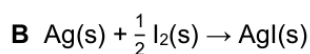
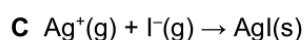
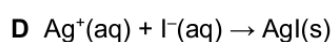
Answer all questions. The marks available are shown against each part. Every question is taken unaltered from a past paper; the source is noted beneath it. In Section A, choose the best answer and write its letter in the box.

Section A · Multiple choice

4 questions · 4 marks

1. Which reaction has an enthalpy change equal to the standard enthalpy of formation of silver iodide? 1 mark

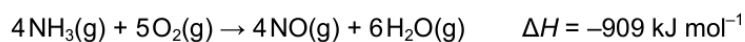
[1 mark]


☐

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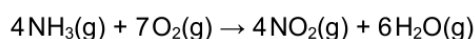
Answer

AQA 7405/3 Chemistry · June 2020 · Paper 3, Question 9

2. Nitrogen dioxide is produced from ammonia and air as shown in these equations 1 mark



What is the enthalpy change (in kJ mol^{-1}) for the following reaction?



[1 mark]

A -679

☐

B -794

☐

C -1024

☐

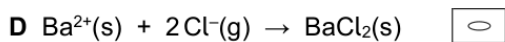
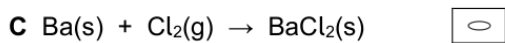
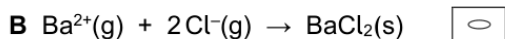
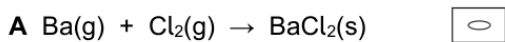
D -1139

☐

Answer

AQA 7405/3 Chemistry · June 2019 · Paper 3, Question 8

3. Which reaction has a standard enthalpy change equal to the standard enthalpy of formation for barium chloride? 1 mark
- [1 mark]**



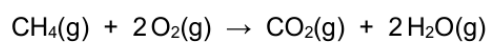
Answer

— AQA 7405/3 Chemistry · June 2023 · Paper 3, Question 10

4. Some bond enthalpies are given. 1 mark

Bond	C–H	O–H	O=O	C=O
Bond enthalpy/ kJ mol ⁻¹	412	463	496	743

Which is the enthalpy change of this reaction in kJ mol⁻¹?



[1 mark]

A +698

☐

B +228

☐

C -228

☐

D -698

☐

Answer

— AQA 7405/3 Chemistry · June 2020 · Paper 3, Question 10

Section B • Structured questions

5 questions • 70 marks

5. This question is about enthalpy of combustion.

9 marks

1

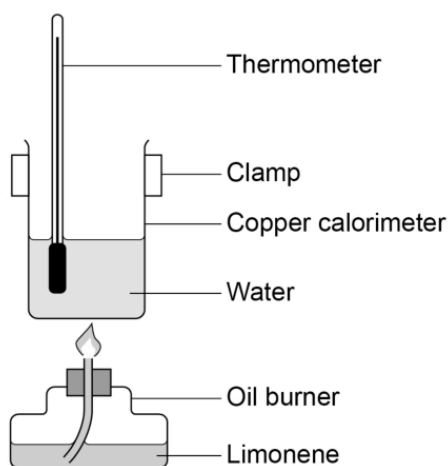
Limonene is found in the skin of citrus fruits.

Figure 6 shows a diagram of the apparatus used in an experiment to determine a value for the enthalpy of combustion of limonene.

When 1.31 g of limonene are burned, the temperature of the 60.0 g of water in the copper calorimeter increases by 52.1 °C

The specific heat capacity of water is 4.18 J K⁻¹ g⁻¹

Figure 6



Calculate a value for the enthalpy of combustion, in kJ mol⁻¹, of limonene (C₁₀H₁₆).

[4 marks]

.....

.....

.....

.....

.....

.....

.....

Enthalpy of combustion

kJ mol⁻¹

2

Table 3 shows values, obtained by different methods, for the enthalpy of combustion of a different liquid hydrocarbon.

Table 3

Method		Enthalpy of combustion / kJ mol ⁻¹
1	Standard enthalpy of combustion $\Delta_c H^\ominus_{298}$	-4194
2	Value calculated from a calorimetry experiment	-1100
3	Value calculated using mean bond enthalpies	-3159

Suggest reasons for the differences between the values obtained by each of Methods 2 and 3, and the value obtained by Method 1 in **Table 3**.

[5 marks]

— AQA 7405/2 Chemistry · June 2024 · Paper 2, Question 11

6. The molar enthalpy of vaporisation (ΔH_{vap}) of a liquid is the enthalpy change when one mole of liquid is converted to vapour at the boiling point of the liquid.

10 marks

A student does an experiment to determine ΔH_{vap} for water.

The student:

- places a large beaker on a balance
- pours 500 cm³ of water into the beaker
- uses a 2.4 kW heater to raise the temperature of the water to 100 °C
- records the mass of the beaker and hot water
- uses the 2.4 kW heater to boil the water for 100 s
- records the mass of the beaker and remaining water.

The loss in mass is 103 g

1

Calculate ΔH_{vap} for water.[1 kW = 1 kJ s⁻¹]

[3 marks]

 ΔH_{vap} kJ mol⁻¹

Table 2 shows some data about three compounds that all contain the same number of electrons.

Table 2

Compound	CH ₃ CH ₂ OH	CH ₃ CH ₂ NH ₂	CH ₃ OCH ₃
Boiling point / K	352	290	248

2

All three compounds in **Table 2** are polar.
Ethanol is the most polar and ethylamine is the least polar.

Explain why all three molecules are polar and why ethylamine is the least polar.
In your answer refer to the shapes around, and relative electronegativities of, the most electronegative atoms.

[4 marks]

3

Explain the trend in the boiling points of the three compounds.
Refer to the intermolecular forces in all three compounds in your answer.

[3 marks]

— AQA 7405/3 Chemistry · June 2023 · Paper 3, Question 5

7.

A student carried out an experiment to find the temperature rise for a reaction between hydrochloric acid and sodium hydroxide solution.

16 marks

- The student used a measuring cylinder to place 50 cm^3 of 0.400 mol dm^{-3} hydrochloric acid into a glass beaker.
- The student recorded the temperature at one-minute intervals for three minutes.
- At the fourth minute the student added 50 cm^3 of 0.400 mol dm^{-3} sodium hydroxide solution and stirred to mix the solutions, but did not record the temperature.
- The student recorded the temperature at one-minute intervals for a further eight minutes.

The results are shown in **Table 3**.

Table 3

Time/min	0	1	2	3	4	5	6	7	8	9	10	11	12
Temperature / °C	19.8	19.8	19.8	19.8		21.4	21.7	21.6	21.5	21.4	21.3	21.2	21.1

1

Plot a graph of temperature against time on the grid opposite.
Use your graph to find the temperature rise, ΔT , at the fourth minute.
Show your working on the graph by drawing suitable lines of best fit.

[5 marks]

 ΔT _____ °C

2

The uncertainty in each of the temperature readings from the thermometer used in this experiment was $\pm 0.1^\circ\text{C}$

Calculate the percentage uncertainty in the value for the temperature rise.

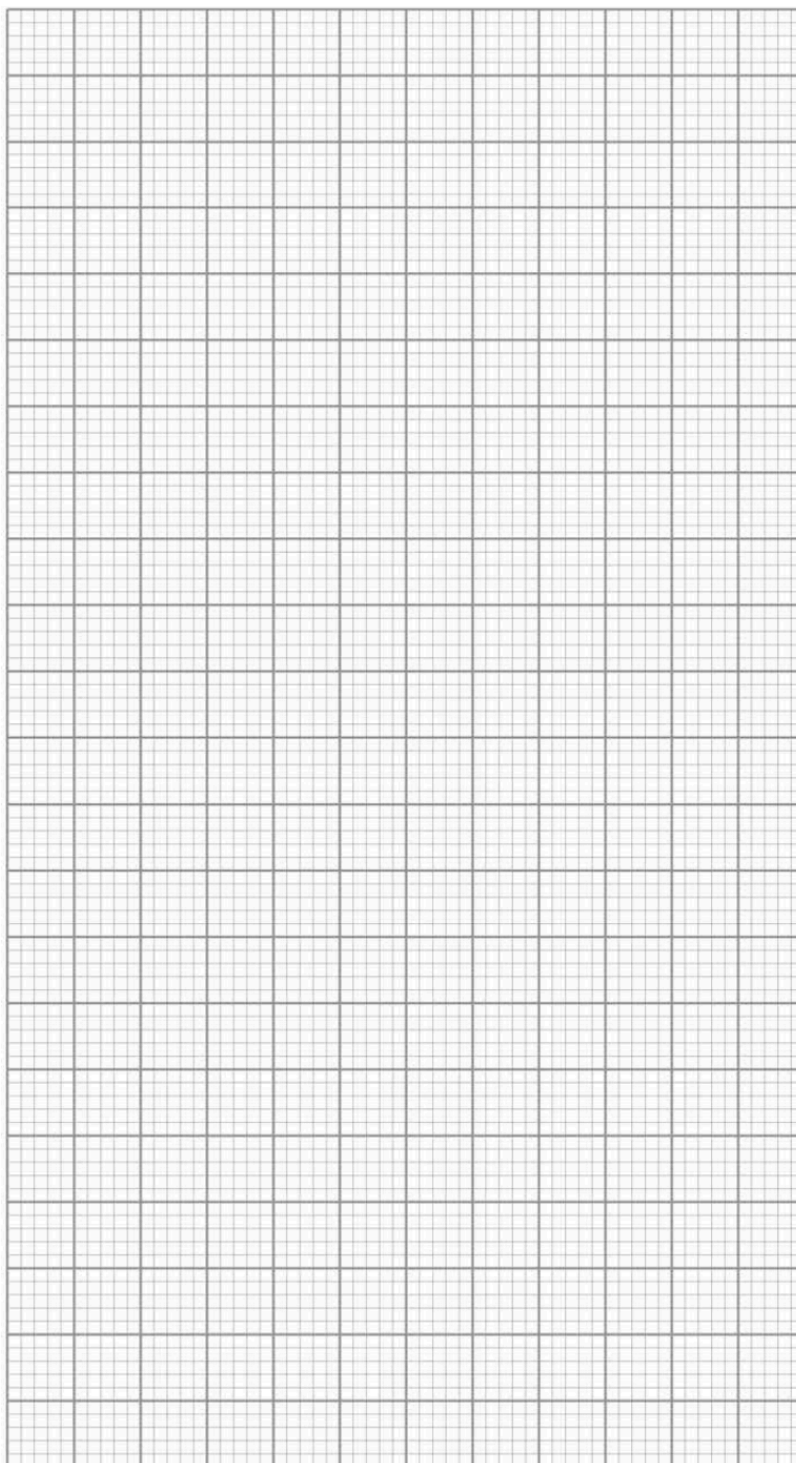
[1 mark]

Percentage uncertainty

3

Suggest a change to the experiment that would minimise heat loss.

[1 mark]



4

Suggest and explain another change to the experiment that would decrease the percentage uncertainty in the use of the same thermometer.

[2 marks]

5

A second student completed an experiment to determine the enthalpy of neutralisation for the reaction between ethanedioic acid solution (HOOC⁻COOH) and potassium hydroxide solution.

The student added 25 cm³ of 0.80 mol dm⁻³ ethanedioic acid solution to 75 cm³ of 0.60 mol dm⁻³ potassium hydroxide solution.
The temperature increased by 3.2 °C

Give an equation for the reaction between ethanedioic acid solution and potassium hydroxide solution.

Calculate the enthalpy change (ΔH) per mole of water formed in this reaction.

Assume that the specific heat capacity of the reaction mixture is 4.2 J K⁻¹ g⁻¹

Assume that the density of the reaction mixture is 1.00 g cm⁻³

[5 marks]

Equation

 ΔH

 kJ mol⁻¹

6

In a similar experiment to that in Question **04.5**, the enthalpy of neutralisation for the reaction between sulfuric acid and potassium hydroxide solution was found to be $-57.0 \text{ kJ mol}^{-1}$ per mole of water formed.

Suggest an explanation for the difference between this value and your answer to Question **04.5**.

(If you were unable to obtain an answer to Question **04.5** you should assume a value of $-28.5 \text{ kJ mol}^{-1}$. This is **not** the correct answer.)

[2 marks]

— AQA 7405/3 Chemistry · June 2018 · Paper 3, Question 4

8.

The oxidation of propan-1-ol can form propanal and propanoic acid. The boiling points of these compounds are shown in **Table 1**.

16 marks

Table 1

Compound	Boiling point / °C
propan-1-ol	97
propanal	49
propanoic acid	141

In a preparation of propanal, propan-1-ol is added dropwise to the oxidising agent and the aldehyde is separated from the reaction mixture by distillation.

1

Explain, with reference to intermolecular forces, why distillation allows propanal to be separated from the other organic compounds in this reaction mixture.

[3 marks]

2

Give **two** ways of maximising the yield of propanal obtained by distillation of the reaction mixture.

[2 marks]

1

2

[2 marks]

[3 marks]

[illegible]

Enthalpy of combustior

kJ mol⁻¹

5

A mixture of isomeric alkenes is produced when pentan-2-ol is dehydrated in the presence of hot concentrated sulfuric acid. Pent-1-ene is one of the isomers produced.

Name and outline a mechanism for the reaction producing pent-1-ene.

[4 marks]

Name of mechanism

Mechanism

6

A pair of stereoisomers is also formed in the reaction in Question 03.5.

Name the less polar stereoisomer formed.
Explain how this type of stereoisomerism arises.

[2 marks]

Name _____

Explanation

9.

This question is about biofuels.

19 marks

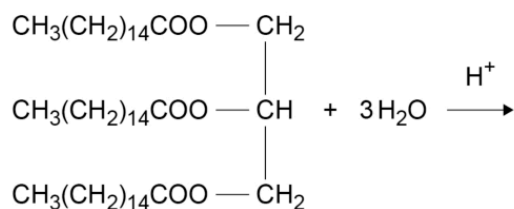
Palmitic acid, $\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$, can be made by hydrolysis of the triester in palm oil under acidic conditions.

Palmitic acid can be used as a biofuel.

1

Complete the equation for the hydrolysis of the triester in palm oil under acidic conditions.

[2 marks]



2

Palmitic acid burns in air.

In a calorimetry experiment, combustion of 387 mg of palmitic acid increases the temperature of 0.150 kg of water from 23.9 °C to 37.5 °C

Calculate a value, in kJ mol^{-1} , for the enthalpy of combustion of palmitic acid in this experiment.

Give your answer to the appropriate number of significant figures.

The specific heat capacity of water is $4.18 \text{ J K}^{-1} \text{ g}^{-1}$

[5 marks]

Enthalpy of combustion

kJ mol⁻¹

3

State how the value calculated in Question **08.2** is likely to differ from data book values.

Give one reason, other than heat loss, for this difference.

[2 marks]

Difference

Reason

4

A sample of a different biofuel, made from sewage sludge, is found to contain 37.08% carbon, 5.15% hydrogen and 24.72% oxygen by mass. The rest of the sample is sulfur.

Calculate the empirical formula of this biofuel.

[3 marks]

Empirical formula

5

Complete combustion of the biofuel made from sewage sludge produces the greenhouse gas carbon dioxide.

Suggest **one** other possible environmental problem with the complete combustion of this biofuel.

State the formula of the pollutant responsible for this problem.

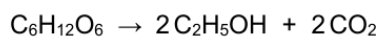
[2 marks]

Environmental problem

Formula

6

Ethanol is a biofuel that can be produced by the fermentation of glucose.



Glucose has the structural formula shown.

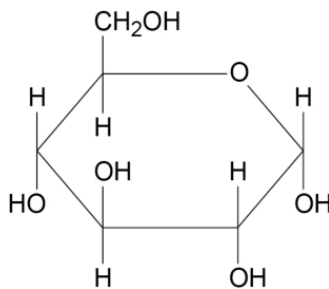


Table 3 shows some mean bond enthalpy values.

Table 3

	C–H	C–C	C–O	C=O	O–H
Mean bond enthalpy / kJ mol ⁻¹	412	348	360	805	463

Use the equation and the data in **Table 3** to calculate an approximate value of ΔH for the fermentation of glucose. For this calculation you should assume that all the substances are in the gaseous state.

[3 marks]

ΔH

kJ mol⁻¹

7

The carbon dioxide produced from fermentation can be reacted with steam to make more ethanol.

The equation for this reaction is



Table 4 shows some standard enthalpies of formation.

Table 4

	CO ₂ (g)	O ₂ (g)	C ₂ H ₅ OH(g)	H ₂ O(g)
$\Delta_f H^\ominus$ / kJ mol ⁻¹	-394	0	-235	-242

Use the data in **Table 4** to calculate a standard enthalpy change value for this reaction.

[2 marks]

Standard enthalpy change

kJ mol^{-1}

— AQA 7405/2 Chemistry · June 2023 · Paper 2, Question 8