Past-paper walk-through

Enthalpy change, ΔH ▪ 5.1

eXercise

Questions in this set

- 9701/11 N25 Q7 ▪ 1 mark
- 9701/11 N25 Q8 ▪ 1 mark
- 9701/12 N25 Q9 ▪ 1 mark
- 9701/12 N25 Q10 ▪ 1 mark
- 9701/14 N25 Q10 ▪ 1 mark
- 9701/33 N25 Q2 ▪ 11 marks
- 9701/34 N25 Q1 ▪ 11 marks

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 7

9701/11 N25 ▪ Q7 ▪ 1 mark

7 When 1.0 mol of ethanoic acid, CH_3COOH, in aqueous solution is neutralised by an excess of aqueous sodium hydroxide, 55 kJ mol^{-1} of energy is released.

Which statement about this reaction is correct?

A The reaction is exothermic because only bond breaking takes place.

B The reaction is exothermic because only bond forming takes place.

C The reaction is exothermic because more energy is given out in breaking bonds than is taken in to form bonds.

D The reaction is exothermic because more energy is given out in forming bonds than is taken in to break bonds.

Solution 7

Answer: **D**

Why

- Bond breaking absorbs energy and bond forming releases it – both happen in every reaction.
- The reaction is exothermic because more energy is given out forming the new bonds than is taken in breaking the old ones.
- So A and B are wrong to claim that only one of the two processes occurs.

Question 8

9701/11 N25 ▪ Q8 ▪ 1 mark

8 In an experiment, 1.60 g of a fuel is burnt. 45.0% of the energy released is absorbed by 200 g of water. The temperature of the water rises from 18.0 °C to 66.0 °C.

What is the total energy released per gram of fuel burnt?

A 25 100 J **B** 55 700 J **C** 89 200 J **D** 143 000 J

Solution 8

Answer: **B**

Why

- Energy absorbed by the water $= 200 \times 4.18 \times 48.0 = 40\,100$ J.
- That is only 45.0% of the total, so the total released is $40\,100 / 0.450 = 89\,200$ J.
- Per gram: $89\,200 / 1.60 = 55\,700$ J; C is the total, not the value per gram.

Question 9

9701/12 N25 ▪ Q9 ▪ 1 mark

9 When 0.47 g of a hydrocarbon is completely burnt in air, the energy released heats 200 g of water from 23.7 °C to 41.0 °C.

What is the amount of energy absorbed, in Joules, by the water?

A $0.47 \times 4.18 \times 17.3$

B $0.47 \times 4.18 \times (273 + 17.3)$

C $200 \times 4.18 \times 17.3$

D $200 \times 4.18 \times (273 + 17.3)$

Solution 9

Answer: **C**

Why

- $q = mc\Delta T$, and m is the mass of *water* being heated, 200 g.
- The temperature change is $41.0 - 23.7 = 17.3$, and a change in °C equals a change in K, so nothing is added.
- So $q = 200 \times 4.18 \times 17.3$; A uses the fuel's mass instead of the water's.

Question 10

9701/12 N25 ▪ Q10 ▪ 1 mark

10 One commercially available ‘heat pad’ contains iron, activated carbon and water. The ‘heat pad’ is activated by air. This causes the pad to get hotter.

Which statement describes the chemical reaction occurring in the ‘heat pad’ when it is exposed to air?

A The reaction is endothermic and iron gains electrons.

B The reaction is endothermic and iron loses electrons.

C The reaction is exothermic and iron gains electrons.

D The reaction is exothermic and iron loses electrons.

Solution 10

Answer: **D**

Why

- The pad gets hotter, so the reaction gives out energy – it is exothermic.
- Air activates it because the iron is being oxidised, that is, it rusts.
- Oxidation is loss of electrons, so the iron loses electrons.

Question 10

9701/14 N25 ▪ Q10 ▪ 1 mark

10 In an experiment to measure the enthalpy change of neutralisation of hydrochloric acid, $20\,cm^3$ of solution containing 0.04 mol of HCl is placed in a plastic cup of negligible heat capacity.

A $20\,cm^3$ sample of aqueous sodium hydroxide containing 0.04 mol of NaOH, at the same initial temperature, is added and the temperature rises by 15 K.

If the heat capacity per unit volume of the final solution is $4.2\,J\,K^{-1}\,cm^{-3}$, what is the enthalpy change of neutralisation of hydrochloric acid?

A $\dfrac{20 \times 4.2 \times 15}{0.04}\,J\,mol^{-1}$

B $40 \times 4.2 \times 15 \times 0.08\,J\,mol^{-1}$

C $\dfrac{40 \times 4.2 \times 15}{0.04}\,J\,mol^{-1}$

Question 10

D $\frac{20 \times 4.2 \times 15}{0.08}\,\text{J mol}^{-1}$

Solution 10

Answer: **C**

Why

- The final solution is $20 + 20 = 40$ cm^3, and the whole of it warms up.
- $q = 40 \times 4.2 \times 15$, using the heat capacity per cm^3.
- The neutralisation forms 0.04 mol of water, so divide by 0.04 to get the value per mole.

Question 2

9701/33 N25 ▪ Q2 ▪ 11 marks

2 When hydrated sodium thiosulfate is dissolved in water the temperature of the liquid changes. You will carry out an experiment to determine the enthalpy change, ΔH, when one mole of hydrated sodium thiosulfate dissolves in water.

FA 3 is hydrated sodium thiosulfate, $Na_2S_2O_3 \cdot 5H_2O$.

(a) Method

- Support the cup in the 250 cm^3 beaker.
- Use the 50 cm^3 measuring cylinder to transfer 30.0 cm^3 of distilled water into the cup.
- Measure the temperature of the water in the cup. Record this in the space for results.
- Weigh the container with **FA 3**. Record the mass.
- Tip all the **FA 3** into the cup.
- Stir the mixture until the minimum temperature is obtained. Record this temperature.
- Weigh the container with any residual **FA 3**. Record the mass.
- Calculate and record the mass of **FA 3** added.
- Calculate and record the temperature change.

Question 2

Results

Question 2

I	
II	
III	
IV	

[4]

(b) Calculations

(i) Calculate the amount, in mol, of hydrated sodium thiosulfate added.

Question 2

(ii) Calculate the energy change, in J, in your experiment.

Question 2

(iii) Calculate the enthalpy change, ΔH, in $kJ\,mol^{-1}$, when 1.00 mol of hydrated sodium thiosulfate dissolves in water. Show your working.

Question 2

sign *value* [1]

(c) The value calculated in **(b)(iii)** can be used to determine the enthalpy change, ΔH_r, for the following reaction.

$$Na_2S_2O_3(s) + 5H_2O(l) \rightarrow Na_2S_2O_3 \cdot 5H_2O(s)$$

Outline the method of one further experiment you would need to carry out to obtain the data necessary to calculate the value of ΔH_r.

Show how you would use your results from this experiment and **(b)(iii)** to calculate ΔH_r.

Do **not** carry out your experiment.

Question 2

Question 2

[4]

[Total: 11]

Qualitative analysis

For each test you should record all your observations in the spaces provided.

Examples of observations include:

- colour changes seen
- the formation of any precipitate and its solubility (where appropriate) in an excess of the reagent added
- the formation of any gas and its identification (where appropriate) by a suitable test.

You should record clearly at what stage in a test an observation is made.

Where no change is observed, you should write ‘no change’.

Where reagents are selected for use in a test, the name or correct formula of the element or compound

Question 2

must be given.

Question 2

must be given.

If any solution is warmed, a boiling tube must be used. If a solid is heated, a hard-glass test-tube must be used.

Rinse and reuse test-tubes and boiling tubes where possible.

No additional tests should be attempted.

Solution 2

(a) Mark scheme

- I
- 6 correct unambiguous headings shown, with units, in list / table
- ▪
- (mass of) container + FA 3 / solid / Na2S2O3 ▪ 5H2O
- ▪
- (mass of) container (empty OR with residual FA 3)
- ▪
- (mass of) FA 3 / solid / Na2S2O3 ▪ 5H2O OR mass used OR mass added

Solution 2

- ▪
- initial temperature / thermometer reading
- ▪
- lowest / minimum / final temperature / thermometer reading
- ▪
- temperature change / decrease
- Mass units: /g OR in g OR (g) OR g by every reading
- Temperature units: / °C OR in °C OR (°C) OR °C by every reading
- 1
- II All readings shown to appropriate precision

Solution 2

- ▪
- all four balance / thermometer readings shown
- ▪
- both thermometer readings to .0 OR .5
- ▪
- both weighings consistently to either 2 d.p. OR to 3 d.p.
- 1
- III Subtractions correctly calculated
- ▪
- mass of solid correct AND temperature change correct

Solution 2

- 1
- IV ΔT is within 1.0 ºC of expected temperature change for the mass used
- 1

Solution 2

(b)(i)

Mark scheme

- Correctly calculates
- amount of FA 3 = mass FA 3 in 2(a) / 248.2 mol
- AND
- answer given to 2–4 s.f.
- 1

Solution 2

(b)(ii) Mark scheme

- Correctly calculates
- energy change $= 30 \times 4.18 \times \Delta T$ J
- AND
- answer given to 2 – 4 sf
- 1
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Solution 2

(b)(iii) Mark scheme

- Correctly uses
- (b)(ii) / (b)(i) $\times$ 1000
- AND
- plus sign shown
- AND
- answer given to 2 – 4 sf
- 1

Solution 2

(c) Mark scheme

- M1 repeating experiment with Na2S2O3 OR adding Na2S2O3 in water **M2**
- any two from:
- ▪
- known volume of water
- ▪
- known mass of solid
- ▪
- measuring the temperature change. **M3**

Solution 2

- indicating that use of Hess's law is needed M4
- $\Delta Hr = \Delta H$ from their additional experiment – (b)(iii)
- 4
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- October/November 2025
- FA 4 is acidified Fe2(SO4)3(aq); FA 5 is Al 2(SO4)3(aq); FA 6 is HCOOH(aq); FA 7 is CH3CH(OH)CH3(l)

Question 1

9701/34 N25 ▪ Q1 ▪ 11 marks

1 Sodium carbonate can be manufactured using a two-step process. The first step involves making sodium hydrogencarbonate, $NaHCO_3$, which is then converted into sodium carbonate, Na_2CO_3, in the second step of the process by the following reaction.

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(l) + CO_2(g)$$

In this experiment you will determine the enthalpy change, ΔH_r, for this reaction. You will do this by calculating the enthalpy changes when separate samples of sodium hydrogencarbonate and sodium carbonate are added to excess hydrochloric acid, $HCl(aq)$. You will then combine these values using Hess's law.

$$NaHCO_3(s) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l) + CO_2(g) \qquad \Delta H_1$$

$$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g) \qquad \Delta H_2$$

FB 1 is 2.0 mol dm^{-3} hydrochloric acid, HCl.
FB 2 is sodium hydrogencarbonate, $NaHCO_3$.
FB 3 is sodium carbonate, Na_2CO_3.

Question 1

(a) Method

Experiment 1

- Support a cup in the 250 cm^3 beaker.
- Use the 25 cm^3 measuring cylinder to transfer 20.0 cm^3 of **FB 1** into the cup.
- Weigh the container with **FB 2**. Record the mass.
- Measure the temperature of the acid in the cup. Record this temperature.
- Carefully add all of the **FB 2**, in small portions to avoid acid spray. Stir to dissolve. Record the lowest temperature.
- Reweigh the container with any residual **FB 2**. Record the mass.
- Calculate and record the mass of **FB 2** used.
- Calculate and record the decrease in temperature.

Experiment 2

- Support the second cup in the 250 cm^3 beaker.
- Use the 25 cm^3 measuring cylinder to transfer 20.0 cm^3 of **FB 1** into the second cup.
- Weigh the container with **FB 3**. Record the mass.
- Measure the temperature of the acid in the cup. Record this temperature.
- Carefully add all of the **FB 3**, in small portions to avoid acid spray. Stir to dissolve. Record

Question 1

Carefully add all of the **FB 2**, in small portions to avoid acid spray. Stir to dissolve. Record the highest temperature.

- Reweigh the container with any residual **FB 3**. Record the mass.
- Calculate and record the mass of **FB 3** used.
- Calculate and record the increase in temperature.

Keep FB 1 for use in Question 3.

Results

Question 1

I	
II	
III	
IV	

[4]

(b) Calculations

(i) Calculate the amount, in mol, of **FB 2** that reacts with **FB 1** and the amount, in mol, of **FB 3** that reacts with **FB 1**.

Experiment 1	Experiment 2

Question 1

amount of **FB 2** = ... mol	amount of **FB 3** = ... mol

[2]

(ii) Calculate the energy changes, in J, for each reaction.

Experiment 1	**Experiment 2**

Question 1

energy change = ... J	energy change = ... J

[1]

(iii) Calculate the enthalpy change, ΔH, in $kJ\,mol^{-1}$ for each reaction.

Experiment 1	**Experiment 2**

Question 1

ΔH_1 = ... kJ mol^{-1} *sign* *value*	ΔH_2 = ... kJ mol^{-1} *sign* *value*

[2]

(iv) Construct an enthalpy cycle and use Hess's law to determine the enthalpy change, ΔH_r, for the reaction shown.
Show your working.

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(l) + CO_2(g)$$

(If you were unable to calculate values in **(b)(iii)** then assume that ΔH_1 is +27.3 kJ mol^{-1} and that ΔH_2 is –24.9 kJ mol^{-1}. These may **not** be the correct values.)

Question 1

Question 1

Question 1

sign *value*

[2]

[Total: 11]

Solution 1

(a) Mark scheme

- I
- Unambiguous headings AND units for all six recorded readings and calculated values in experiment 1:
- ▪
- (mass of) container + FB 2 / solid / g
- ▪
- (mass of) container (+ residue) / g
- ▪

Solution 1

- (mass of) FB 2 / solid (used / added) / g
- ▪
- initial temperature OR temperature of FB 1 / oC
- ▪
- final temperature / oC
- ▪
- temperature change / oC
- 1
- II
- ▪

Solution 1

- All four weighings recorded to same decimal places (either 2 or 3).
- ▪
- All four temperatures recorded to .0 or .5°C
- 1
- III Correct subtractions to give all four calculated values:
- ▪
- mass of FB 2 used and mass of FB 3 used
- ▪
- changes in temperature for experiments 1 and 2.
- 1

Solution 1

- Accuracy (Q) marks
- Calculate the candidate's temperature to mass ratio for experiment 1 to 2 d.p.: Ratio = T (experiment 1) / mass of FB2.
- Calculate the supervisor's ratio for experiment 1 to 2 d.p.
- Calculate the difference, , between the candidate's value (rounded to 2 d.p.) and the supervisor's value (rounded to 2 d.p.).
- IV award if 0.50
- 1

Solution 1

(b)(i) Mark scheme

- M1: Correctly calculates both Mr values:
- Mr of $NaHCO_3$ = 84 AND Mr of Na_2CO_3 = 106
- 1
- M2: Correctly calculates both amounts using subtractions from (a)
- n = mass in (a) / Mr (mol)
- AND both answers given to 2–4 sf
- 1

Solution 1

(b)(ii)

Mark scheme

- Correctly calculates both values of energy change
- energy change $= 20 \times 4.18 \times \Delta T$ (J)
- AND both answers given to 2–4 sf
- 1

Solution 1

(b)(iii) Mark scheme

- M1: Correct display of ΔH = (b)(ii) / (b)(i) for experiment 1 or experiment 2.
- 1
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- October/November 2025
- Question Answer
- M2: Correctly uses ΔH = (b)(ii) / ((b)(i) $\times$ 1000)
- AND + sign for $\Delta H1$ AND – sign for $\Delta H2$
- AND both answers given to 2–4 sf

Solution 1

- 1

Solution 1

(b)(iv) Mark scheme

- M1: Drawing of enthalpy cycle
- 1
- M2: Correctly calculates $\Delta Hr = 2\Delta H1 - \Delta H2$
- 1
- 9701/34
- October/November 2025
- Question Answer