Exam Papers Practice

5.1 Energetics

Mark Schemes

Course	DP IB Chemistry
Section	5. Energetics / Thermochemistry
Topic	5.1 Energetics
Difficulty	Hard

To be used by all students preparing for DP IB Chemistry SL
Students of other boards may also find this useful

1

The correct answer is **C** because:

- **The energy transferred as heat is given by the equation; *$q = mc\Delta T$***
  - Where q is heat transferred (J), m is the mass of water (g), c is the specific heat capacity (J g^{-1} °K^{-1}), ΔT is the temperature change (K)
- **Known quantities:**
  - Mass of water; 500 g
  - Temperature change; (68 – 25)°C
  - Specific heat capacity of water; 4.2 J g^{-1} °K^{-1}
- **Substitution into the equation:**

$$q = mc\Delta T = 500 \times 4.2 \times (68 - 25)$$

- We can see from the question that this represents 30% of the energy released by the combustion of the fuel
  - **The total energy released:**

    $500 \times 4.2 \times (68 - 25) \times \frac{100}{30}$

- The question asks for the total energy released per gram of fuel burnt, 2.5 g of fuel was used in the experiment
- **Energy per gram of fuel**

$$500 \times 4.2 \times (68 - 25) \times \frac{100}{30} \times \frac{1}{2.5}$$

$$\frac{500 \times 4.2 \times (68 - 25) \times 100}{30 \times 2.5}$$

2

The correct answer is **A** because:

	Steps	Calculation
1	Calculate the temperature change of the hydrochloric acid	24.4 - 17.6 = 6.8 °C
2	Calculate $q = mc\Delta T$ for the hydrochloric acid	25.0 x 4.18 x 6.8
3	Calculate the temperature change of the sodium hydroxide	24.4 - 18.5 = 5.9 °C
4	Calculate $q = mc\Delta T$ for the sodium hydroxide	25.0 x 4.18 x 5.9
5	Determine the total energy evolved by adding the two energy changes	(25.0 x 4.18 x 6.8) + (25.0 x 4.18 x 5.9)

B is incorrect as	this is calculating the average enthalpy change per chemical, not the overall enthalpy change
C is incorrect as	this is calculating the enthalpy change based on the average temperature increase of the two chemicals
D is incorrect as	the total volume has been used for each $q = mc\Delta T$ calculation instead of the actual volume of each chemical

This question is unusual but when the starting temperatures of the two liquids are different, you should calculate $q = mc\Delta T$ for each solution and then add your answers together

3

The correct answer is **B** because:

	Steps	Calculation
1	Convert the heat energy from MJ to J	$0.1 \times 10^6 = 100000$ J
2	Convert the mass from kg to g	$2.5 \times 10^3 = 2500$ g
3	Rearrange $q = mc\Delta T$ for c	$c = \frac{q}{m\Delta T}$
4	Substitute the values into the equation	$\frac{100000}{2500 \times 44.4}$

A is incorrect as	the mass of aluminium hasn't been converted into g
C is incorrect as	the mass of aluminium hasn't been converted into g **and** the heat energy hasn't been converted into J
D is incorrect as	the heat energy hasn't been converted into J

4

The correct answer is **C** because:

	Steps	Calculation
1	$q = mc\Delta T$	500 x 0.448 x 12.7
2	Convert q from J to kJ	$\frac{500 \times 0.448 \times 12.7}{1000}$
3	Number of moles of iron, n	$\frac{500}{55.85}$
4	$\Delta H = \frac{q}{n}$	$\frac{500 \times 0.448 \times 12.7}{1000} \times \frac{55.85}{500}$
5	Simplify	$\frac{0.448 \times 12.7 \times 55.85}{1000}$

A is incorrect as	q hasn't been converted into kJ
B is incorrect as	the number of moles hasn't been inverted when changing from ÷ to x, e.g. $\frac{500 \times 0.448 \times 12.7}{1000} \times \frac{500}{55.85}$
D is incorrect as	the iron cube is absorbing the heat energy which is an endothermic process and has a positive ΔH value

5

The correct answer is **D** because:

- To calculate enthalpy change, the energy released during the reaction and the amounts of reactants are required
    - The energy released is calculated from $q = mc\Delta T$
    - The amounts of reactants can give the value of m in $q = mc\Delta T$ and the moles required to calculate $\Delta H = \frac{q}{n}$
- The **system** describes the reaction mixture
    - Heat transfer to the system is heat that is warming the system
    - Therefore, heat transfer to the system will cause the temperature change for the reaction to be closer to the true value meaning that the experimental data values will be higher / closer to the expected values

A is incorrect as	heat lost through convection will be heating the surroundings, not the system, which **will** lead to a lower experimental value than expected
B is incorrect as	the standard state of water is liquid, therefore, some heat energy has been wasted in causing the state change, which **will** lead to a lower experimental value than expected
C is incorrect as	an inadequate supply of oxygen causes incomplete combustion, which **will** lead to a lower experimental value than expected

6

The correct answer is **D** because:

- The standard enthalpy of formation, ΔH^{θ}_{f}, is the enthalpy change when **one mole** of a compound is formed from it elements, under standard conditions
  - 7 moles of SO_2 are formed
  - Therefore, this equation **cannot** be described as a standard enthalpy of formation equation
- The standard enthalpy of combustion, ΔH^{θ}_{c}, is the enthalpy change when **one mole** of a substance is burnt in excess oxygen, under standard conditions, with **all reactants and products in their standard states**
  - The standard physical state of S_7 is solid **but** S_7 is not the most energetically stable allotrope of sulfur
  - Therefore, this is not a standard state for the element sulfur
  - This means that this equation **cannot** be described as a standard enthalpy of combustion equation
- The enthalpy change of reaction, ΔH_r, is the enthalpy change when the reactants in the stoichiometric equation react to give the products
  - In the question, this enthalpy is **not** a standard enthalpy as there is no Θ symbol
  - The enthalpy change of reaction does not require reactants and products to in their standard states
  - Therefore, this equation **can** be described as an enthalpy of reaction equation

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The correct answer is **B** because:

- $\Delta H = \frac{q}{n} = \frac{mc\Delta T}{n}$ which rearranges to $\Delta T = \frac{\Delta H \times n}{m \times c}$

	Steps	Calculation
1	Convert ΔH from kJ to J	1216 x 1000 = 1216000
2	Number of moles of cyclohexane, n	$\frac{(186.79 - 186.29)}{84.18} = \frac{0.5}{84.18}$
3	Substitute into $\Delta T = \frac{\Delta H \times n}{m \times c}$	$\Delta T = \frac{1216000}{50.00 \times 4.18} \times \frac{0.5}{84.18}$
4	Simplify	$\Delta T = \frac{608000}{50.00 \times 4.18 \times 84.18}$ $\Delta T = \frac{60800}{5.00 \times 4.18 \times 84.18}$
5	Final temperature = initial temperature + ΔT	19.6 + ΔT $19.6 + \frac{60800}{5.00 \times 4.18 \times 84.18}$

A is incorrect as	ΔH was not converted from kJ to J
C is incorrect as	ΔH was not converted from kJ to J **AND** the number of moles was not inserted into the ΔT equation correctly
D is incorrect as	the number of moles was not inserted into the ΔT equation correctly

8

The correct answer is **D** because:

- Statement I is correct
  - There will still be heat loss by heating the material in the combustion chamber as some lost through the top of the combustion chamber
  - But, overall, more of the heat produced goes directly into heating the water of the combustion chamber
- Statement II is correct
  - The chamber calorimeter has a constant air supply which reduces the amount of incomplete combustion
  - **Careful:** In calorimetry, there is a large focus on incomplete combustion - the wording of this statement is flipped to talk about complete combustion
- Statement III is correct
  - Fuel is lost through evaporation but this will not happen as readily in the combustion chamber

A, **B** & **C** are incorrect as	they do not include all three correct statements

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The correct answer is **A** because:

- Statement I is correct
  - With no further information, you have to assume that the solutions are at the same temperature
  - If they were at different temperatures, then you would have to calculate *q* for each solution
- Statement II is correct
  - While there will be a precipitate of barium sulfate formed, the assumption is that there will still be 50 cm^3 of water formed which is equal to 50 g

- Statement III is incorrect
  - The barium sulfate precipitate will absorb some of the heat energy
  - This is in the reaction vessel and therefore part of the system

B, **C** & **D** are incorrect as	they include statement III

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The correct answer is **C** because:

- The energy transferred can be calculated using $q = mc\Delta T$
- Statement I is incorrect
  - **Careful:** The mass of magnesium is not needed to calculate the energy transferred
  - It is needed to calculate the molar enthalpy change
- Statement II is correct
  - The mass of water is m in the equation
- Statement III is correct
  - The temperature change is ΔT in the equation

A, **B** & **D** are incorrect as	they include statement I