Exam Papers Practice

5.1 Energetics

Mark Schemes

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

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

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The correct answer is **D** because:

- **The energy transferred as heat is given by the equation; $q = mc\Delta T$**
- **Known quantities:**
  - Volume of solution; $30 + 30 = 60\ cm^3$
  - Aqueous solution are assumed to have the same density as water, $1\ g\ cm^{-3}$
  - Temperature change; 0.5 °C
    - Change in temperature does not need to be converted into Kelvin
  - Specific heat capacity; $4.18\ J\ g^{-1}\ K^{-1}$
- **Substitution into the equation:**

$$q = mc\Delta T = 60 \times 4.18 \times 0.5$$

- **Divide this answer by the moles** as the question asked for the molar enthalpy change.
- **Inputting into the formula**

$$\text{moles, n} = \text{conc} \times \frac{vol}{1000} = 0.025 \times \frac{30}{1000}$$

- **Divide the energy released by the moles to get the energy per mol**

$$\frac{q}{n} = \frac{60 \times 4.18 \times 0.5 \times 1000}{0.025 \times 30}$$

- **Convert into kJ by dividing by 1000 and add a minus sign as the reaction is exothermic (as the temperature rose)**

$$-\frac{60 \times 4.18 \times 0.5 \times 1000}{0.025 \times 30 \times 1000}$$

You can cancel 1000 from top and bottom so the final expression is

$$-\frac{60 \times 4.18 \times 0.5}{0.025 \times 30}$$

IMPORTANT NOTE– As this is an acid / base reaction the molar enthalpy change can also be expressed as ΔH_{neut}. The molar enthalpy change will be calculated per mole of water formed. The numerical answer will be the same

2

The correct answer is **B** because:

- The **standard enthalpy change of neutralisation** ($\Delta H^{\ominus}_{neut}$) is the enthalpy change when one mole of water is formed by the reaction of an acid with alkali under standard conditions
- **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 (°C)
- **Known quantities from the question**
  - The total volume of the solution = 75 + 75 = 150 cm^3
  - The density of the solution is assumed to be the same as water, 1 $g\,cm^{-3}$
  - Specific heat capacity of the solution = 4.18 $J\,g^{-1}\,K^{-1}$
  - Temperature change = 14 °C
- **Substitution into the equation:**

$$q = mc\Delta T = 150 \times 4.18 \times 14$$

- This gives the top line of the equation
- **Divide this answer by the moles** as the question asked for the molar enthalpy change.
  - Note: When given the concentrations of two solutions normally It would be the limiting reagent that is used to calculate the molar enthalpy.
- Here, both solutions react in a 1:1 molar ratio and are of the same concentration so we can just use the moles of one of them.
- **Calculating moles:**

$$n = conc \times \frac{vol}{1000}$$

$$= 3.0 \times \frac{75}{1000} = 3.0 \times 0.075$$

- This gives the bottom line of the equation **add a minus sign as the reaction is exothermic (as the temperature rose)**
- **Therefore the correct calculation is B:**
  - $-\frac{(150 \times 4.18 \times 14)}{(3.0 \times 0.075)}\,J\,mol^{-1}$

3

The correct answer is **C** because:

- The **standard enthalpy of formation** ($\Delta H_f^{\ominus}$) is the enthalpy change when one mole of a compound is formed from its elements under standard conditions.
  The reactants and products must be in their standard states.
- Enthalpy changes of formation can be exothermic or endothermic (+ / −)
- The **standard enthalpy change of combustion** ($\Delta H_c^{\ominus}$) is the enthalpy change when one mole of a substance is burnt in excess oxygen under standard conditions. The reactants and products must be in their standard states
- Enthalpy changes of combustion are always exothermic (−)
- The **standard enthalpy change of neutralisation** ($\Delta H_{neut}^{\ominus}$) is the enthalpy change when one mole of water is formed by the reaction of an acid with alkali under standard conditions.
- Enthalpy changes of neutralisation are always exothermic (−)

4

The correct answer is **B** because:

- The equation to calculate the heat energy absorbed is $q = mc\Delta T$
  - m = the mass of water = b
  - c = the specific heat capacity of water = d
  - ΔT = the temperature change = y

A is incorrect as	the mass of ethanol has been used, not the mass of water
C is incorrect as	the temperature does not need adjusting as you have been given the temperature rise. This will be the same whether the units are °C or K
D is incorrect as	the equation is incorrect and the mass of ethanol has been used and the temperature does not need adjusting

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The correct answer is **C** because:

- The equation to calculate the heat energy absorbed is $q = mc\Delta T$
  - $\Delta T = \frac{q}{mc}$
  - $\Delta T = \frac{504}{110 \times 0.448} = 10.23$

A is incorrect as	the mass of iron has not been converted into g **Remember:** The standard unit for mass, in chemistry, is g
B is incorrect as	the value for the specific heat capacity of water has been used in the calculation (4.18) rather than the specific heat capacity of iron that is given, e.g. $\Delta T = \frac{504}{110 \times 4.18}$
D is incorrect as	the calculation has been performed the wrong way up, e.g. $\Delta T = \frac{110 \times 0.448}{504} = 9.78 \times 10^{-2}\ K$

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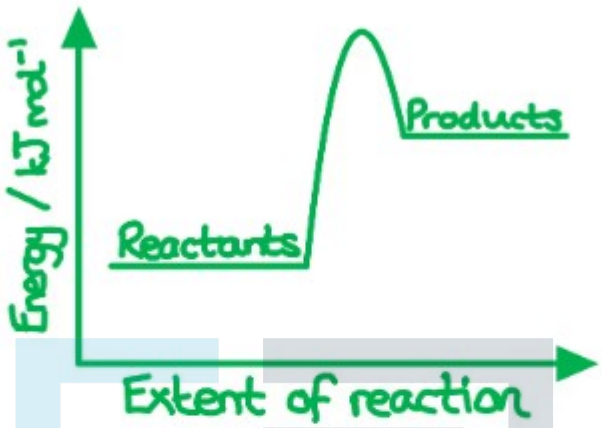
The correct answer is **C** because:



- Statement I is incorrect
  - The products are higher energy than the reactants which means that they are less stable
- Statement II is correct
  - Endothermic reactions have a positive enthalpy change
- Statement III is correct
  - The temperature of the surroundings decreases as the reaction absorbs thermal energy

A, **B** & **D** are incorrect as	statement I is not correct

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The correct answer is **A** because:

- Statement I is correct
  - The density of the solution is assumed to be the same as water, i.e. 1 g cm^{-3}
- Statement II is correct
  - For the purposes of the calculation, the specific heat capacity of the solution is assumed to be the same as water, i.e. 4.18 J g^{-1} K^{-1}
- Statement III is incorrect
  - One of the reactants is used in excess to ensure a complete reaction occurs

B, **C** & **D** are incorrect as	statement III is not correct

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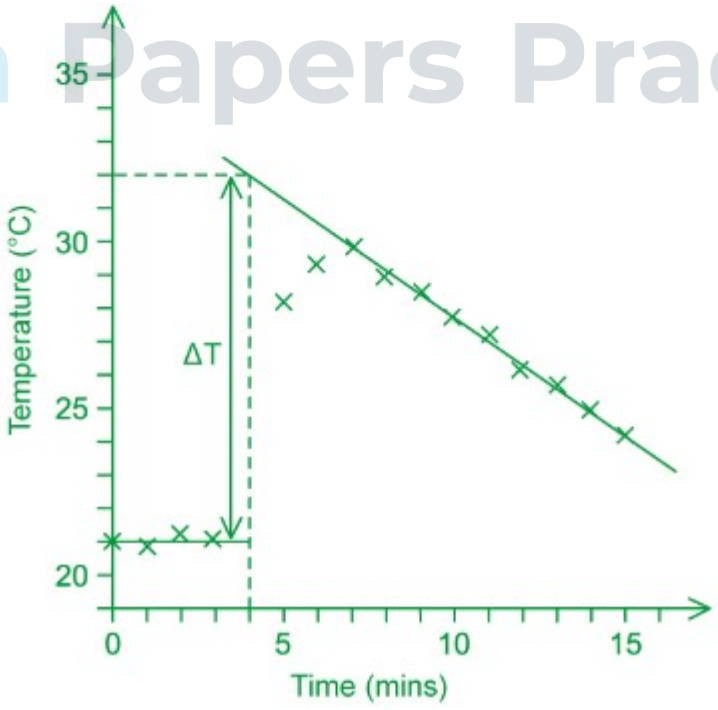
The correct answer is **C** because:



- The line through the points for 5 minutes onwards has to be extrapolated back past 4 minutes
- The initial temperature, at 4 minutes, is 21 °C
- The temperature from the extrapolated line at 4 minutes is ≈ 32 °C
- Therefore, the temperature change is 32 - 21 = 11 °C

A is incorrect as	this is the value that would be achieved by drawing a smooth curve through all the points for 5 minutes onwards and then extrapolating back to 4 minutes
B is incorrect as	this is the value calculated using the initial temperature and the maximum temperature achieved
D is incorrect as	this is the temperature that is read off the axis when the line through the points for 5 minutes onwards is extrapolated all the way back to the y-axis

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The correct answer is **C** because:

- The enthalpy change for all three reactions can be described as the enthalpy of reaction, $\Delta H^{\ominus}_{r}$
- Reaction 1 is the neutralisation of nitric acid with ammonia
- Reaction 2 is the thermal decomposition of copper carbonate
- Reaction 3 is the combustion of sulfur **AND** the formation of sulfur dioxide

A, **B** & **D** are incorrect as	reaction 2 is not combustion because there is no reaction with oxygen and it is not formation because it starts from a compound

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The correct answer is **B** because:

- An open system allows the transfer of matter and energy across the boundary
  - e. more reactants can be added to the reaction system and it can be heated / cooled
- A closed system only transfers energy across the boundary
  - e the reaction system can be heated
- Isolated systems do not allow the transfer of matter or energy across the boundary
  - These systems are the rarest of the three systems

A, **C** & **D** are incorrect because	statement II is incorrect