5.3 Bond Enthalpy

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Course	DP IB Chemistry
Section	5. Energetics / Thermochemistry
Topic	5.3 Bond Enthalpy
Difficulty	Medium

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

1

The correct answer is **C**

- Use the formula $\Delta H = \Sigma$ bonds broken - Σ bonds formed
- There are 6 N–F bonds in the product because each molecule of NF_3 contains three 3 N–F bonds and there are two molecules formed
- Substituting into the formula

$$\Delta H = \sum(945 + (3 \times 159)) - \sum(6 \times N\text{–}F) = -246$$

$$-(6 \times N\text{–}F) = -246 - (945 + (3 \times 159))$$

$$+(6 \times N\text{–}F) = +246 + (945 + (3 \times 159))$$

$$(N - F) = \frac{+246 + (945 + (3 \times 159))}{6}$$

Exam tip: Always use brackets to separate the bond energy terms from the mathematical operations. It is very easy to get your signs wrong if you don't do this

2

The correct answer is **C** because:

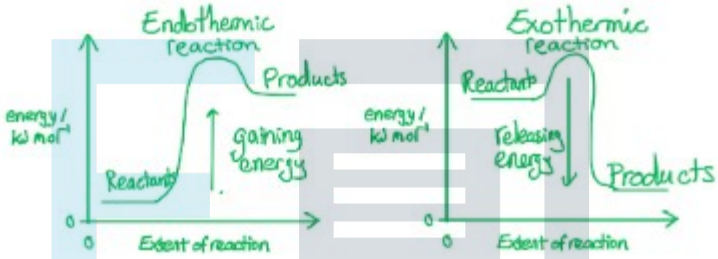
- The **standard enthalpy change of combustion** ($\Delta H_c^{\ominus}$) is the enthalpy change when one mole of a substance is burnt in excess oxygen under standard conditions. The reactants and products must be in their standard states
- Enthalpy changes of combustion are always exothermic
- **Equation:** $\Delta H = \sum bonds\ broken - \sum bonds\ formed$
- **Bonds broken:**
  - This is endothermic, and therefore the sum of the bonds broken is positive
  - $2 \times (C-H) = 2 \times a = 2a$
  - $1 \times (C \equiv C) = b$
  - $2.5 \times (O=O) = 2½ \times c = 2½c$
  - Sum of bonds broken = $(2a + b + 2½c)$
- **Bonds formed:**
  - This is exothermic, and therefore the sum of the bonds formed is negative
  - $2 \times (O-H) = e \times 2 = 2e$
  - $4 \times (C=O) = d \times 4 = 4d$
  - Sum of bonds broken = $(2e + 4d)$
- $\Delta H = \sum bonds\ broken - \sum bonds\ formed$
- $\Delta H = (2a + b + 2½c) - (2e + 4d)$ kJ

Careful counting of bonds and the sign of the energy change are really important in getting these type of problems right

3

The correct answer is **A** because:

- The reaction R → S is endothermic as ΔH is positive, so it is gaining energy
- The reaction S → T is exothermic as ΔH is negative, so it is releasing energy
- The energy profile diagrams for exothermic and endothermic reactions are shown below:



- When the two reactions are combined the energy increases then decreases as seen in option **A**
- S can be isolated so it is an intermediate; this is shown as a small dip in energy.

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The correct answer is **C** because:

- The activation energy for the reverse endothermic reaction is the energy needed for the products to be converted back into the reactants
- This is the energy from the products to the peak of the 'hump' in the line

A is incorrect as	this does not correspond to activation energy
B is incorrect as	this is the activation energy for the forward reaction (reactants → products)
D is incorrect as	this is the ΔH of the forward reaction

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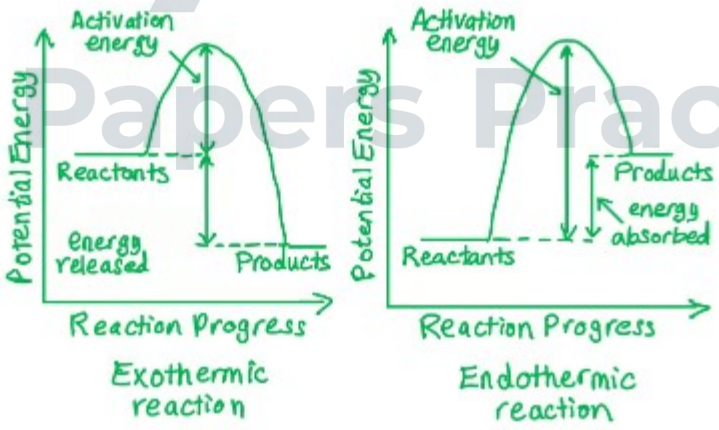
The correct answer is **A** because:

- The activation energy is minimum energy particles must possess to break bonds to start a chemical reaction
  - This is the energy from the reactants to the 'hump' in the line



  - Therefore, $E_3 - E_2$ for this question

B is incorrect as	this is the ΔH of the forward reaction
C & D are incorrect as	these do not correspond to the activation energy

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The correct answer is **D** because:

- Combustion is an exothermic process, even when it is incomplete
- Use the formula ΔH_r = Σ bonds broken - Σ bonds formed
- **Bonds broken:**
  - (3 x C-H) + (C-O) + (O-H) + (O=O)
  - (3 x 414) + (358) + (463) + (498)
- **Bonds formed:**
  - (C=O) + (4 x O-H)
  - (804) + (4 x 463)
- ΔH_c = Σ bonds broken - Σ bonds formed

  = [(3 x 414) + (358) + (463) + (498)] - [(804) + (4 x 463)]

  = -95 kJ mol^{-1}

A is incorrect as	the calculation only accounts for each type of bond, not how many there are of each bond
B is incorrect as	this calculation is using the wrong equation, it is using Σ bonds formed - Σ bonds broken
C is incorrect as	the OH bond in methanol has been mistaken for a CH bond in the calculation

Exam tip: Draw out the displayed formulae of all the chemicals involved in the reaction and tick them off as you use them - that way you don't miss any bonds

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The correct answer is **B** because:

- Statements I and III are true
  - A bond enthalpy may be inaccurate when compared to data tables because it is not an average value
  - Bond enthalpies may be inaccurate as they do not account for intermolecular forces
- Statement II is false
  - Average bond enthalpies are only valid for gases

A, **C** & **D** are incorrect as	statement II is not correct

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The correct answer is **B** because:

- The question states that the graph must show the reaction that would proceed most rapidly
- All the reactions are carried out at the same temperature
- This means that we are looking for the graph with the lowest activation energy (either graph **B** or **D**)
- An exothermic reaction will have a negative enthalpy value as the chemical reaction loses energy to the surroundings as reactants form products (graph **B**)

A is incorrect as	it has higher activation energy than **B**
C & **D** are incorrect as	they are both endothermic reactions and produce a positive entropy change

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The correct answer is **B** because:

- Bond breaking requires energy and is, therefore, endothermic
- Bond formation releases energy and is, therefore, exothermic

A, **C** & **D** are incorrect as	they have at least one incorrect statement about bond breaking and / or bond formation

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The correct answer is **D** because:

- Equation II is the reaction where oxygen in the upper atmosphere undergoes homolytic fission to form two oxygen free radicals
- Equation III shows the exothermic step of oxygen free radicals reacting with another oxygen molecule to form ozone
- Equation I is the reaction of an ozone molecule to form an oxygen molecule and an oxygen free radical
- All three reactions are required to maintain the concentration of ozone in the upper atmosphere

A, **B** & **C** are incorrect as	all three reactions are involved in maintaining the concentration of ozone in the upper atmosphere