InkChemistry

ANSWER BOOK

Mean bond enthalpies

Energetics · Unit C04

AQA 3.1.4.4 · OCR A 3.2.1

13 questions · 43 marks

NAVY EDITION

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SECTION A · Short, 1 to 2 marks

A1 MBE-Q12

B1 every bond involved is in a diatomic molecule, so each bond enthalpy is an exact value, not a mean. **B1** all the species are gases in their standard states, so no change of state is left out of the calculation. [2]

A2 MBE-Q14

B1 the bond enthalpy calculation treats hexane and the water as gases. **B1** condensing the seven moles of water formed releases more energy than vaporising the hexane takes in, so the standard value, with both liquid, is more exothermic. [2]

SECTION B · Standard, 3 to 5 marks

B1 MBE-Q6

M1 bonds broken: ½ × 945 + 1½ × 436 = 472.5 + 654 = 1126.5. **M1** bonds made: 3 N–H, so -46 = 1126.5 - 3(N–H). **M1** 3(N–H) = 1126.5 + 46 = 1172.5. **A1** N–H = +391 kJ mol^{-1} to three significant figures. [4]

B2 MBE-Q10

B1 breaking a bond has a positive enthalpy change: energy is taken in to overcome the attraction between the shared pair and the nuclei. **B1** making a bond has a negative enthalpy change, releasing the same energy. **B1** energy is taken in to break the C–H and O=O bonds in the reactants and released when the C=O and O–H bonds in the products form. **B1** more energy is released making the product bonds than is taken in breaking the reactant bonds, so heat is released overall; reject 'breaking bonds releases energy'. [4]

B3 MBE-Q15

B1 both are the enthalpy change to break one mole of a bond with everything in the gaseous state, and both are positive. **B1** a bond dissociation enthalpy refers to one specified bond in one particular molecule. **B1** a mean bond enthalpy is averaged over that type of bond in a range of compounds, so for a given molecule it is an approximation. **B1** the energy to break a C–H bond depends on the other atoms attached to the carbon, and even differs between the successive bonds in methane, so the table gives an average. [4]

B4 MBE-Q1

B1 the enthalpy needed to break one mole of a given type of covalent bond. **B1** with the molecules in the gaseous state. **B1** averaged over a range of different compounds; ignore 'average' or 'mean' alone without the range. [3]

B5 MBE-Q4

M1 bonds broken: 436 + 243 = 679. **M1** bonds made: 2 × 432 = 864. **A1** ΔH = 679 - 864 = -185 kJ mol^{-1}, to three significant figures. [3]

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B6 MBE-Q11

B1 mean bond enthalpies are averages over many compounds, not the actual values for the bonds in ethane. **B1** bond enthalpies apply to gases, so the calculation gives the three moles of water as steam. **B1** the standard value forms liquid water, and condensing it releases extra energy, so the standard value is more exothermic; reject heat loss, since nothing was measured. [3]

B7 MBE-Q13

B1 the second bond is broken in an OH fragment, not in H_2O, so its environment is different. **B1** the arrangement of electrons around the oxygen has changed once one hydrogen has gone, so the bond has a different strength. **B1** the mean for water is (498 + 428) ÷ 2 = 463 kJ mol^{-1}. [3]

B8 MBE-Q17

B1 the reactants rise to separate gaseous atoms as all their bonds are broken, taking in energy. **B1** the atoms fall to the products as the new bonds form, releasing energy. **B1** ΔH is the difference between the energy taken in and the energy released, from the reactant level to the product level. [3]

B9 MBE-Q19

B1 the two nitrogen atoms are joined by a triple bond, which is short, holding three shared pairs close to both nuclei. **B1** the N≡N bond enthalpy is very high, 945 kJ mol^{-1}, the strongest bond in the table. **B1** any reaction must begin to break this bond, so the activation energy is high and few collisions at room temperature have enough energy. [3]

B10 MBE-Q20

B1 only one C–H bond is broken, and it is the first one in methane, CH_3–H, not an average C–H bond. **B1** breaking that bond takes 439 kJ mol^{-1}, more than the mean of 413 kJ mol^{-1}, so more energy is taken in than the calculation allows. **B1** using 439 makes the answer 26 kJ mol^{-1} less exothermic, -96 kJ mol^{-1}, close to the measured value. [3]

SECTION C · Long, 6 marks or more

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C1 MBE-Q16 **Indicative content** [6]

B1 bond enthalpies need only the structures of the molecules, so they give an estimate for compounds whose enthalpies of formation have never been measured. **B1** the values are means over many compounds, not the actual bond energies in the molecules reacting, so the answer is only approximate. **B1** bond enthalpies apply only to gases, so a reaction with a liquid or solid in its standard state needs a change-of-state correction. **B1** where every bond is in a diatomic molecule, as in hydrogen with chlorine, the values are exact and the agreement with the data book is close. **B1** a Hess cycle uses measured enthalpies of formation of the actual compounds in their standard states, so it is more accurate where those data exist. **B1** bond enthalpies are therefore best used as an estimate, usually within about ten per cent for gases, with a formation cycle preferred whenever its data are available.

Levels

Level 3 (5–6 marks) both sides are weighed: the usefulness of mean bond enthalpies where formation data do not exist, their inaccuracy from being averages and applying to gases only, the exact case of diatomic molecules, and the greater accuracy of a formation cycle, ending with a justified view of when each should be used.

Level 2 (3–4 marks) the mean-value and gas-phase limits are given and the formation cycle called more accurate; the case for bond enthalpies, or when each method should be used, is not made.

Level 1 (1–2 marks) bond enthalpies are called approximate with no reason, or more accurate because each bond is measured separately.

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