ANSWERS: Bond enthalpy

A close-up of a white sheet

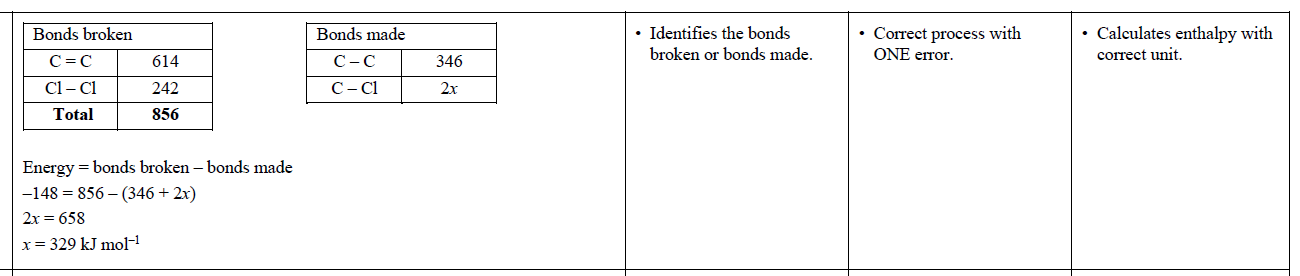
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**2022**

A close-up of a white background

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2021



2020

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| **2019** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
|  |  | • Correctly calculation total bonds broken.  OR  Correctly identifies bonds made in a formula. | • Correct process with minor error / omission. | • Correct answer with unit. |

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| **2018** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
|  |  | • Identifies the bonds broken. | • Correct process with error. | • Calculates N-H bond enthalpy  with correct unit. |

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| **2017** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
|  |  | Identifies the bonds broken and bonds formed for both equations.  OR  Correct process for one reaction. | Correct process giving the  correct answer for one  reaction. | Correct process and answers for both reactions, including correct units (kJ mol–1), and states **Reaction** **2** releases more energy. |

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| **2016** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
|  | Bond breaking Bond making  C=C 614 C–C × 3 1038  C–C × 2 692 C–H × 10 4140  C–H × 8 3312 5178 kJ mol–1  H–H 436  5054 kJ mol–1  Δr*H*° = Bond breaking – bond making  Δr*H*° = 5054 kJ mol–1 – 5178 kJ mol–1  Δr*H*° = –124 kJ mol–1  OR  Bond breaking Bond making  C=C 614 C–C 346  H–H 436 C–H × 2 414 × 2  1050 kJ mol–1 1174 kJ mol–1  Δr*H*° = Bond breaking – bond making  Δr*H*° = 1050 – 1174  Δr*H*° = –124 kJ mol–1 | * Identifies the two relevant bonds broken (C = C and   H – H). | * Correct process with minor errors. Identifies which bonds are broken and which bonds are formed. | * Correct answer, including correct sign and unit. |

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| **2015** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
|  | C2H4(*g*) + Br2(*g*) → C2H4Br2(*g*)  Bonds broken Bonds formed  C=C 614 C–C 346  Br–Br 193 C–Br 2 × 285  807 916  Δr*H*o = ΣBond energies(bonds broken) – ΣBond energies(bonds formed)  = 807 – 916 (or 2463 – 2572)  = –109 kJ mol-1  (*Alternative calculation that includes the breaking and reforming of four C-H bonds will also be accepted to Excellence level*.) | * Correctly identifies the two relevant bonds broken, ie C=C and Br-Br, or formed, ie C–Br and C–C(qualitative)   OR  One step in the calculation correct.  OR  Correct answer with no working. | Correct process for calculation with one error. | Calculation correct with correct sign and units. |

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| **2014** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
|  | ∆r*H*o = ∑(bonds broken) – ∑(bonds formed)  Bonds broken  H–H = 436  ½ × O=O = ½ × 498  Total = 685 kJ mol–1  Bonds formed  2 × O–H  ∑(bonds formed) = ∑(bonds broken) – ∆r*H*o  = 685 – (– 242)  = 927 kJ mol–1  2 × O–H = 927 kJ mol–1  **O–H** = 464 (463.5) kJ mol–1 | * Identifies bonds broken and bonds formed. * Bonds broken = 685 kJ mol–1. | * Correct process for calculating bond enthalpy, with one error. | * Correctly calculates the bond enthalpy of O–H. |

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| **2013** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
|  | |  |  | | --- | --- | | **Bonds broken**: | **Bonds formed**: | | C–H × 1  Cl–Cl × 1 | C–Cl × 1  H–Cl × 1 | | 414 + 242 = 656 | 324 + 431= –755 |   656 kJ + (–755 kJ) = –99.0 kJ mol–1  OR   |  |  | | --- | --- | | **Bonds broken**: | **Bonds formed**: | | C–H × 4  Cl–Cl × 1 | C–Cl × 1  C–H x 3  H–Cl × 1 | | 1656+ 242 = 1898 | 324 + 1242+ 431= 1997 |   1898 kJ + (–1997 kJ) = –99.0 kJ mol–1 | * Identifies bonds broken and formed. | * Process for calculating ∆r*H*° correct, however one **minor** error | Correctly calculates ∆r*H*°, with units and negative sign. |

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| **2012** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
| (i)  (ii) | Enthalpy change = Σ(bonds broken) – Σ(bonds formed)  *x* = *E*(C=O)  Bonds broken = 7(C–H) + 2(C–C) + 1(C–O) + 1(O–H) + 4.5(O=O)  = 7(414) + 2(346) + 358 + 463 + 4.5(498)  = 2898 + 692 + 358 + 463 + 2241  Bonds broken = 6 652 kJ mol–1  Bonds formed = 6(C=O) + 8(O–H)  = 6(*x*) + 8(463)  = 6(*x*) + 3704  –2010 = (6652) – (6(*x*) + 3704)  –2010 = 2948 – 6 (*x*)  –4958 = – 6(*x*)  *E*(C=O) = **826 kJ mol–1** OR **826.3 kJ mol–1**  The **bond enthalpy** is the energy required to break one mole of bonds between (pairs of) atoms (in the gaseous state).  C=O bond enthalpy is larger than C–O bond enthalpy as more energy is required to break the double bond than a single bond. | * calculates the difference of sum of bonds broken minus sum of bonds formed. * Correct process for substitution of bond enthalpies. * Correct answer of   *E*(C=O) = 826 kJ mol-1.   * Correct definition of bond enthalpy. * Understands that the double bond requires more energy to break than the single bond. |  |  |

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| **2011** | Enthalpy change = ∑bonds broken – ∑bonds formed  Bonds broken Bonds formed  C − H 413 × 6 = 2478 C=O 745 × 4 = 2980  C − O 358 × 2 = 716 O−H 463 × 8 = 3704  O − H 463 × 2 = 926  O = O 498 × 3 = 1494 \_\_\_\_\_\_  +5614 − 6684  Δr*H* = −1070 kJ mol–1  OR  Bonds broken = 4688 Bonds formed = 5758 | Ie, equation – needs to have ∑ if has equation only  OR  Correct answer but wrong sign.  OR  EITHER bonds broken OR bonds formed identified or calculated correctly. | Correct answer with no working  OR  Correct method with minor number transcription error (ie some calculator error with correct numbers.  OR  Correct answer with wrong / no unit. | Answer correct with some calculation done.  With correct units. |

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| **2010** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
|  | Enthalpy change = bonds broken – bonds formed  *x* = *E*(O–H)   1. Bonds broken = 5(C–H) + 1(C–C) + 1(C–O) + 1(O–H) + 3(O=O)   (b) = 5(412) + 348 + 360 + *x* + 3(496)  (c) Bonds broken = 4256 + *x* *(4256)*   1. Bonds formed = 4(C=O) + 6(O–H) 2. = 4(743) + 6(*x*)   (c) = 2972 + 6(*x*) *(2972 + 5x)*  (d) –1379 = (4256 + *x*) – (2972 + 6(*x*))  (d) –1379 = 1284 – 5 (*x*)  (d –2663 = – 5(*x*)  *x* (O–H) = **533 kJ mol–1** OR **532.6 kJ mol–1** | Correct method. (Shows understanding of relationship between enthalpy and bond-making and breaking.)  Ie, equation  OR  (a) OR (b)  (Calculation of the bonds broken and bonds formed may have ONE omission, eg miss out a C–C bond.). | Correct answer with no working.  OR  Correct method with minor number transcription error.  OR  Correct answer with wrong sign.  OR  Correct answer with wrong / no unit.  OR  Both (c) statements correct.  OR  One (d) correct. | Correct answer with working and correct unit. |

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| **2009** | **Evidence** | **Achievement** | **Achievement with Merit** | **Achievement with Excellence** |
|  | Sum of bond energies broken – sum of bond energies formed  = (339 + 391) – (431 + 286)  = 730 – 717  = 13 kJ mol–1  OR  (breaking and forming all bonds)  = (1242 + 339 + 1173) – (1242 + 286 + 782 + 431)  = 2754 – 2741  = 13 kJ mol-1 | Correct values for bonds broken and bonds formed (ignore signs) | * Correct answer |  |

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| 2008 | (i) The energy required to break a bond  (ii)  Me Hyd comb  ∆cHO = ΣEB(reactants) – ΣEB(products)  = 3EB(N–H) + EB(N–N) + EB(N–C) + 3EB(C–H) + 2.5 EB(O=O)  – 2EB(C=O) – EB(N≡N) – 6EB(O–H)  = 3×391 + 163 + 286 + 3×414 + 2.5×498  –2×804 – 941 – 6×463  = – 1218 kJ mol–1 (or heat released = 1218 kJ / kJ mol–1) Bonds broken Bonds formed 3N–H 391 × 3 = 1173 2C=O 804 × 2 = 1608 N–N 163 = 163  941 = 941  C–N 286 = 286 6O–H 463 × 6 = 2778  3C–H 414 × 3 = 1242  2O=O 498 × 2 = 1245  Adds to = 4109 Adds to = 5327 | * • Definition correct   OR   * • Value for either bonds broken (4109) or bonds formed (5327). | * • Definition correct   AND  Value of energy released = 1218  (ignore sign and units) | • Definition correct  AND  • calculation correct  i.e. either  ∆cH°  = – 1218 kJ mol–1  OR  heat released  = 1218 kJ / kJ mol–1 |

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