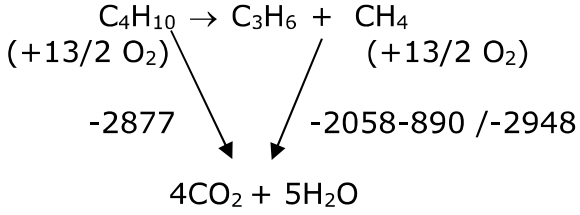
Question Number	Acceptable Answers	Reject	Mark
20(a)(i)	(Different) boiling temperatures/ boiling points ALLOW Range of boiling temperatures		**(1)**

Question Number	Acceptable Answers	Reject	Mark
20(a)(ii)	**Cracking**: breaking of carbon chain (in a hydrocarbon/ alkane) to give shorter chain hydrocarbon(s)/ smaller molecules OR breaking a hydrocarbon/ alkane to give smaller molecules OR Breaking an alkane to give an alkene **and** (a smaller) alkane/ hydrogen (1) **Reforming**: converting straight chain to a (more) branched chain/ ring/ arene / aromatic compound ALLOW Specific examples (1) IGNORE Makes more useful compounds Converting low octane (fuels) into high octane (fuels)	Just "Breaking a hydrocarbon" Just "Breaking a molecule" Breaking a hydrocarbon to form branched chains or ring structures	**(2)**

Question Number	Acceptable Answers	Reject	Mark
20(a)(iii)	Look at final answer: **+71** (kJ mol^{-1}) scores **3** marks **-71/ 71** (kJ mol^{-1}) scores **2** marks **-5825** (kJ mol^{-1}) scores **1** mark Method:  **MP1** Labelled cycle OR use of $\Delta H = \sum \Delta H_{combustion}$ reactants - $\sum \Delta H_{combustion}$ products (1) **MP2** ΔH = (-2877 -(-2058+ (-890)) (1) **MP3** =**+**71 (kJ mol^{-1}) (1)	Incorrect units	**(3)**

Question Number	Acceptable Answers	Reject	Mark
20(a)(iv)	$C_4H_{10} \rightarrow C_2H_6 + C_2H_4$ OR $C_4H_{10} \rightarrow C_4H_8 + H_2$ OR $C_4H_{10} \rightarrow 2C_2H_4 + H_2$ ALLOW Breakdown of multiple butanes Ignore state symbols, even if incorrect	$C_4H_{10} \rightarrow C_3H_6 + CH_4$ Charged products eg $C_2H_5^+$ Free radicals eg $C_2H_5^{\bullet}$	**(1)**

Question Number	Acceptable Answers	Reject	Mark
20b(i)	Look at final answer: **-2050** (kJ mol^{-1}) or anything correctly rounded from −2046.528 **(-2047, -2046.5, -2046.53)** scores **3** marks **+2050/ 2050** (kJ mol^{-1}) scores **2** marks Incorrect rounding scores 2 marks Correct value without sign scores 2 marks Energy transferred = (200 x 4.18 x 34.0) =28424 (J) IGNORE Sign if given (1) Mol pentane =(1.0/72) = 0.01389 / 0.0139 (1) ΔH = − (-28424 ÷ (1/72 x 1000)) = −2046.528 (kJ mol^{-1}) ALLOW TE from MP 1 and 2 provided moles of pentane is not taken as 1 (1) NOTE Use of 0.0139 mol gives -2044.9 (kJ mol^{-1}) giving 3 marks Use of 0.0138 mol gives -2059.7 (kJ mol^{-1}) giving 2 marks Use of 0.014 mol gives -2030.29 (kJ mol^{-1}) giving 2 marks Ignore SF except one or two		**(3)**

Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	Incomplete combustion OR Loss of pentane by evaporation ALLOW Volume of water too large to heat evenly Water not stirred evenly Small change in mass inaccurate Heat capacity of /energy needed to heat calorimeter not included	Incomplete reaction Loss of water by evaporation Heat losses Conditions not standard Measuring errors Pentane impure	**(1)**

Question Number	Acceptable Answers	Reject	Mark
20(b)(iii)	Pentane is **very** volatile/ has low boiling temperature so risk of explosion OR Has **high** flammability IGNORE Reaction is very exothermic	Just "it is flammable" Vapour is toxic Combustion products/ CO toxic	**(1)**

Question Number	Acceptable Answers	Reject	Mark
20(c)(i)	$C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$ Allow multiples Ignore state symbols even if incorrect		**(1)**

Question Number	Acceptable Answers	Reject	Mark
20(c)(ii)	Bonds broken are four C-C twelve C-H eight O=O (1) Bonds made are ten C=O twelve O-H (1) ALLOW TE from (c)(i) If all five bonds are named but formulae not given eg oxygen-oxygen bonds, max 1 If all five bonds are correctly identified by formula but numbers are incorrect or missing, max 1	O-O single bonds C-O single bonds	**(2)**

Question Number	Acceptable Answers	Reject	Mark
20(c)(iii)	The (total) bond energy of the bonds formed is greater than the bond energy of the bonds broken OR Energy released forming new bonds > energy needed to break old bonds OR The sum of the bond energies of the products is greater than the sum of the bond energies of the reactants.	Just"more bonds are made than broken" Answers referring to energy needed to make bonds Energy contained by bonds in reactants> energy contained by bonds in products	**(1)**

(Total for question 20 = 16 marks)