Hess's Law

Mark Scheme 2

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	The Core Principles of Chemistry
Sub Topic	Hess's Law
Booklet	Mark Scheme 2

Time Allowed: **70 minutes**

Score: **/58**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

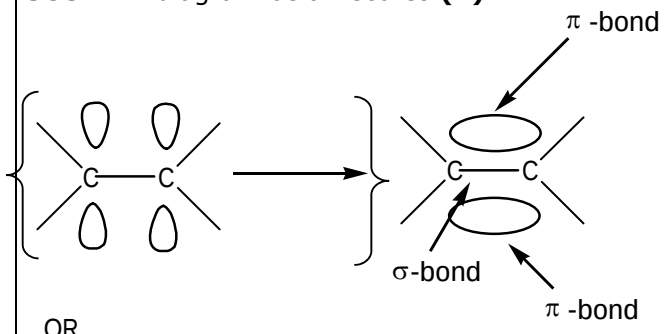
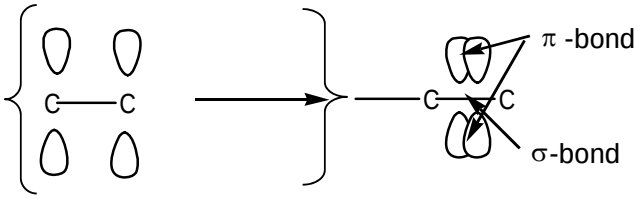
Question Number	Acceptable Answers	Reject	Mark
1(a)	**1st mark – idea of moles / amounts specified** (Enthalpy change when) the number of moles of reactants **ALLOW** (Enthalpy change when) the number of moles of products or substances / just molar quantities / just amounts / just moles **(1)** **2nd mark – idea of an equation** (react as specified in the balanced) **equation** **(1)** **IGNORE** references to (standard) conditions / just 'enthalpy change that occurs during a reaction'	**'One mole** of reactants' / **'One mole** of products' for 1st mark	**2**

Question Number	Acceptable Answers	Reject	Mark
1(b)(i)	(Heat energy absorbed = 100 x 4.2 x 5.5 =) 2310 (J) **ALLOW** 2.3(10) **kJ** IGNORE sign and sf except one sf		**1**

Question Number	Acceptable Answers	Reject	Mark
1(b)(ii)	(Moles NH_4CNS = $\frac{15.22}{76.1}$ =) 0.2(00) (mol) **IGNORE** sf **ALLOW** M_r = 76 for NH_4CNS to give 0.200(3) (mol)		**1**

Question Number	Acceptable Answers	Reject	Mark
1(b)(iii)	$\Delta H_{reaction}$ = +$\frac{2.3(10)}{0.2(00)}$ **x2** = +23.1 (kJ mol^{-1}) = **+**23 (kJ mol^{-1}) to 2 sf **First mark – correct computation of $\Delta H_{reaction}$:** **2 x** [answer to (b)(i) in kJ ÷ answer to (b)(ii) in mol] **(1)** **Second mark – stand alone, for correct rounding:** A final answer to **two** sf **(1)** **Third mark – stand alone, for giving a + sign for endothermic reaction:** **+** sign in front of final answer **(1)** NOTE: **+**12 (kJ mol^{-1}) scores **(2)** (i.e. the 2nd and 3rd marks)	Incorrect units given by the candidate (no 3rd scoring point)	**3**

Question Number	Acceptable Answers	Reject	Mark
1(c)(i)	(Average amount of) energy/enthalpy required to **break one mole** of (covalent) **bonds** **ALLOW** Energy change/enthalpy change to **break one mole** of (covalent) **bonds** **(1)** (in the) **gas / gaseous** (state) **(1)**	Energy/enthalpy **released** OR 'Bonds **formed**/**made**' OR 1 mol of **compound** for 1st mark	**2**

Question Number	Acceptable Answers	Reject	Mark
1(c)(ii)	For a pi/π-bond: Sideways overlap of p-orbitals / overlap of p-orbitals above and below stated or drawn on a diagram **(1)** For a sigma/σ-bond: Head-on overlap of any orbitals, stated or drawn on a diagram **(1)** **MAX (1)** if it is not specified/clear which type of overlap relates to which type of bond **IGNORE** Incorrect diagram **NOTE** **JUST 1st** diagram below scores **(1)** whereas **JUST 2nd** diagram below scores **(2)**  OR  **NOTE:** For the σ-bond, allow any form of 'end-on' overlap of orbitals **MAX (1)** if **only** an UNLABELLED but otherwise correct diagram is given (ie also no words)		**2**

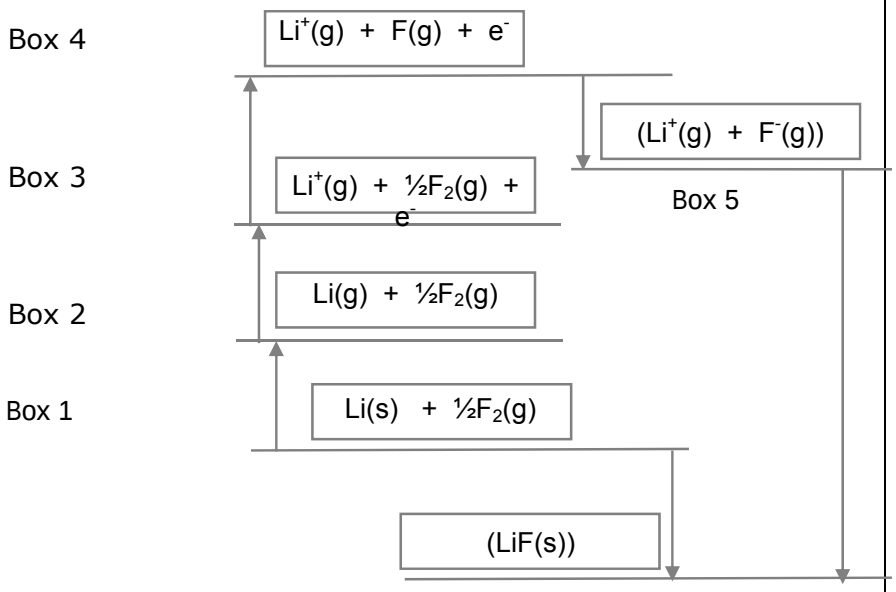
Question Number	Acceptable Answers	Reject	Mark
1(c)(iii)	π-bond is weak(er) OR σ-bond is strong(er) OR The sideways overlap is less effective than the head-on overlap **ALLOW** The two bonds in the (C=C) double bond are not the same strength **IGNORE** References to C=C bond more reactive than C-C bond / 'restricted rotation'	π-bond is stronger than the σ-bond OR C=C bond weaker than C-C bond	**1**

Question Number	Acceptable Answers	Reject	Mark
1(c)(iv)	[FIRST, check the answer on the answer line IF answer = **−1936** (kJ mol^{-1}) award **(3)** marks; **+1936** (kJ mol^{-1}) scores **(2)**] Bonds broken (6 x (C−H) = 6 x 413 + 1 x (C−C) = 1 x 347 + 1 x (C=C) = 1 x 612 + 4½ x (O=O) = 4½ x 498 =) (+)5678 **(1)** Bonds made (6 x (C=O) = 6 x −805 + 6 x (O−H) = 6 x −464 =) (−)7614 **(1)** $\Delta H_{reaction}$ = bonds broken + bonds made = (+)5678 + (−)7614 = −1936 (kJ mol^{-1}) **(1)** **NOTE** 3rd mark CQ on answers calculated for bonds broken and bonds made		**3**

Question Number	Acceptable Answers	Reject	Mark
1(c)*(v)	Under standard conditions/298 K water is a **liquid** OR (Calculations involving) bond energies refer to (water in) **gaseous** state **(1)** Energy released/given out on changing from gas to liquid OR Energy absorbed/taken in on changing from liquid to gas **(1)** **ALLOW max (1)** if state that 'bond energies are average values (from a range of compounds)' **IGNORE** References to 'heat losses' / 'incomplete combustion'		**2**

(Total for Question 1 = 17 marks)

Question Number	Acceptable Answers	Reject	Mark
2(a)	(The energy / enthalpy change / released that accompanies the formation of) **one mole** of a(n ionic) compound **(1)** ALLOW as alternative for compound: lattice /crystal / substance / solid / product / salt from (its) **gaseous ions** **(1)** IGNORE References to 'standard conditions' or any incorrect standard conditions **ALTERNATIVE RESPONSE** If no mark(s) already awarded from above, can answer by giving:- energy change **per mole** / enthalpy change **per mole** **(1)** Li^+(**g**) + F^-(**g**) → LiF(s) **(1)** **NOTE** If lattice energy of dissociation is given (e.g. "energy required to break down 1 mol of an ionic lattice into its gaseous ions") max (1) for the 2nd scoring point 'gaseous ions'	'energy required' / 'energy needed' / 'energy it takes' 'from **one mole of gaseous ions**' (no 2nd mark) Just 'from gaseous **elements**' (no 2nd mark)	**2**

Question Number	Acceptable Answers	Reject	Mark
2(b)(i)	 IGNORE missing electrons / e^- **First mark (Box 1):** **$Li(s) + ½F_2(g)$** **(1)** **Second mark (Box 4):** **$Li^+(g) + F(g)$** $(+e^-)$ **(1)** **Third and Fourth marks (if box 1 is correct):** 'Box 2' as above i.e. $Li(g) + ½F_2(g)$ as above **(1)** 'Box 3' as above i.e. $Li^+(g) + ½F_2(g)$ $(+ e^-)$ as above **(1)** OR 'Box 2' Li(s) + F (g) **(1)** 'Box 3' Li(g) + F(g) **(1)** OR 'Box 2' $Li(g) + ½F_2(g)$ **(1)** 'Box 3' Li(g) + F(g) **(1)**		**4**

	Penalise use of 'Fl' instead of 'F' once only If Box 1 is INCORRECT max (2) for correct transitions e.g if use F(g) or F_2(g) instead of ½F_2(g), then 2 marks available for two correct transitions involving lithium.		

Question Number	Acceptable Answers	Reject	Mark
2(b)(ii)	**ST, CHECK THE FINAL ANSWER** **IF answer = −1046 (kJ mol^{-1}) then** **award (2) marks, with or without working** Otherwise look for −616 = (+159) + (+520) + (+79) + (−328) + ΔH_{LE} **OR** ΔH_{LE} = −616 − [(+159) + (+520) + (+79) + (−328)] **(1)** = −616 − 430 = −**1046** (kJ mol^{-1}) **(1)** NOTE **ALLOW** for **1 mark**: (+)1046 (wrong sign) −186 (+430 instead of −430) (+)186 (+616 instead of −616) −1006.5 (+79 halved to +39.5) −1702 (wrong sign for 328)		**2**

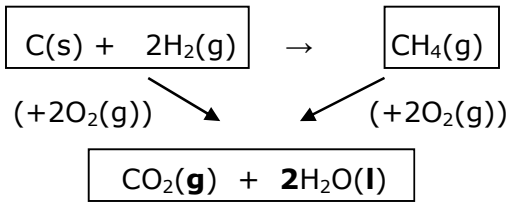
Question Number	Acceptable Answers	Reject	Mark
***2(c)(i)**	ALLOW reverse argument where appropriate (NaF more negative than NaCl because) **First mark** F^- smaller (than Cl^-) ALLOW 'fluorine **ion** is smaller (than a chlorine **ion**') OR F^- larger **charge density** (than Cl^-) **(1)** **Second mark:** F^- (forms) stronger (electrostatic) **attractions** (than Cl^-) IGNORE just 'stronger (ionic) bonds' **(1)** **Penalise ONCE ONLY in (c)(i) and (c)(ii)** the use of the word 'atom(s)' or 'molecule(s)'/ use of **just formulae** such as 'Mg', 'Na', 'F', 'F_2', 'Cl', 'Cl_2', etc. OR **Penalise ONCE ONLY in (c)(i) and (c)(ii)** the use of **words** such as **just** 'magnesium' (instead of magnesium ions/Mg^{2+}) and/or **just** 'fluorine' (instead of fluoride ions/F^-) /and or **just** 'chlorine' (instead of chloride ions/Cl^-) IGNORE Any comments about polarization of the anion (by the cation) / covalent character	"**NaF** is smaller than **NaCl**" F^- has a smaller **atomic** radius than Cl^-	**2**

Question Number	Acceptable Answers	Reject	Mark
***2(c)(ii)**	ALLOW reverse argument where appropriate (NaF less negative than MgF_2 because) **First mark - size:** Mg^{2+} smaller (than Na^+) OR 'Magnesium ion' is smaller (than Na^+) **(1)** **Second mark - charge:** Mg^{2+} has a greater charge (density) (than Na^+) OR 'Magnesium ion' has a greater charge (density) (than Na^+) **(1)** **[NOTE:** It follows that the statement that "Mg^{2+} ions are smaller than Na^+ ions" would score BOTH marks**]** IGNORE Any comments about polarization of the anion (by the cation) / covalent character	"**MgF_2** is smaller than **NaF**" Mg^{2+} has a smaller **atomic** radius than Na^+	**2**

(Total for Question 2 = 12 marks)

Question Number	Acceptable Answers	Reject	Mark
3(a)	(Enthalpy/energy change when) **one mole** of a compound / **one mole** of a substance IGNORE Statements such as "energy released" or "energy required" here **(1)** is formed from its elements (in their standard states, under standard conditions) **(1)** (Standard temperature is) 298 K / 25°C ALLOW '°K' IGNORE References to room temperature (Standard pressure is) 1 atm / 101 kPa / 100 kPa **(1)**	'is formed from its **gaseous** elements'	**3**

Question Number	Acceptable Answers	Reject	Mark
3(b)	$6C(s, graphite) + 7H_2(g) \rightarrow C_6H_{14}(l)$ **ALLOW** 6C(s) / 6C(graphite) Species **and** balancing correct **(1)** State symbols correct **(1)** State symbols mark is dependent on correct species but allow this mark if 14H used instead of $7H_2$ **NOTE** $C_6H_{14}(l) \rightarrow 6C(s, graphite) + 7H_2(g)$ scores **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
3(c)	 **First mark:** Both arrows point downwards **(1)** **Second mark:** CO_2(**g**) + **2**H_2O(**l**) **(1)** **Third mark:** ((1 x −394) + (2 x −286) − (1 x −890) =) **−76** (kJ mol^{-1}) No TE from cycle arrows **(1)**	**2**H_2O(**g**) If incorrect units with a final answer, no 3rd mark	**3**

Question Number	Acceptable Answers	Reject	Mark
3(d)(i)	(+1652÷4 =) (+)**413** (kJ mol^{-1})	**−**413	**1**

Question Number	Acceptable Answers	Reject	Mark
3(d)(ii)	**st mark:** (+2825 — 6 x answer to (d)(i)) ALLOW TE only from a **positive** value given as answer to (d)(i) **(1)** **Second mark:** = (+)347 (kJ mol^{-1}) **(1)** Second mark is CQ on first mark Correct answer with or without working scores **(2)** **NOTE** **−**347 (kJ mol^{-1}) **scores (1)**		**2**

(Total for Question 3 = 11 marks)

Question Number	Acceptable Answers	Reject	Mark
4(a)(i)	$BaCO_3 + 2H^+ \rightarrow Ba^{2+} + CO_2 + H_2O$ IGNORE state symbols even if wrong IGNORE charges $Ba^{2+}CO_3^{2-}$	Cl^- remains on both sides of equation, unless crossed out / "Ba^{2+} **+** CO_3^{2-}" on left-hand side	**1**

Question Number	Acceptable Answers	Reject	Mark
4(a)(ii)	Effervescence / fizzing / bubbles (of gas) **(1)** Solid disappears /dissolves **(1)** IGNORE Tests on gas / just 'vigorous reaction' / any references to temperature change	**Just** "Gas given off"	**2**

Question Number	Acceptable Answers	Reject	Mark
4(b)(i)	$(25 \times 2.00/1000) = 0.05 / 5 \times 10^{-2}$ (mol) Ignore sf		**1**

Question Number	Acceptable Answers	Reject	Mark
4(b)(ii)	$(0.5 \times (5 \times 10^{-2} \times 197.3))$ = 4.9325 / 4.933 / 4.93 / 4.9 (g) TE from (b)(i) Ignore SF except 1		**1**

Question Number	Acceptable Answers	Reject	Mark
4(b)(iii)	So that **all acid** was neutralized / **all acid** reacted / **all acid** used up / **all H^+** used up	So that reaction is complete /to get maximum reaction / "So that all the **$BaCO_3$** is used up" / **Just** "to neutralize the acid" / "To make sure all the **solid** reacts"	**1**

Question Number	Acceptable Answers	Reject	Mark
4(b)(iv)	Filtration/ centrifuging	Decanting	**1**

Question Number	Acceptable Answers	Reject	Mark
4(b)(v)	Theoretical yield = (244 x 5 x 10^{-2} x 0.5) = 6.1(0) (g) **(1)** TE from (b)(i) (244 x ans to b(i) x 0.5) % yield = (5.35 x 100 /6.10) = 87.70492 = 87.7/88% **(1)** OR Moles of crystals = (5.35/244 =) 0.02193 **(1)** % yield = ((0.02193x100/0.025) =) 87.7049 = 87.7/88% [NB If use moles crystals 0.0219 ans=87.6%] **(1)** TE for mol crystals/answer to (b)(i), so 43.9% etc gets **(1)** Correct final answer with no working shown scores both marks Ignore SF except 1	$\frac{4.93}{5.35}$ x 100% = 92% **(0)** $\frac{197.3}{244}$ x 100% = 80.9% **(0)** 87% (as rounding error)	**2**

Question Number	Acceptable Answers	Reject	Mark
4(b)(vi)	**A ONE OF:** Not all solid/product crystallizes Some barium chloride/product remains in solution Product lost during filtration Product/crystals left on filter paper ALLOW 'Transfer losses' / 'loss during the process' Product left on apparatus / product left on glass rod / product left on beaker **IGNORE** Spillages / 'blunders' **NOTE:** 'Loss of products during transfer and incomplete reaction' scores **(0)** as +1 – 1 = 0	Incomplete reaction / Equilibrium reaction / 'side products' / 'side reactions' / 'loss of **reactants** during transfer' / '**reactants** left on apparatus' / 'vapourisation of $BaCl_2$'	**1**

Question Number	Acceptable Answers	Reject	Mark
4(c)(i)	Lattice energy for barium chloride **E** Enthalpy change of atomization of barium **D** Enthalpy change of atomization of Cl_2 to 2Cl **A** First ionization energy of barium **C** Second ionization energy of barium **B** Enthalpy change of formation of barium chloride **F** All correct (3) 4 or 5 correct (2) 2 or 3 correct (1)		**3**

Question Number	Acceptable Answers	Reject	Mark
4(c)(ii)	Twice the (first) electron affinity OR (First) electron affinity (of chlorine/Cl)	If mention of Cl_2 /chlor**ide** / Cl^-	**1**

Question Number	Acceptable Answers	Reject	Mark
4(c)(iii)	180 + 243.4 + 503 + 965 – 697.6 + lattice energy = −858.6 OR **F** = **D** + **C** + **B** + **A** + **X** + **E** OR **E** = **F** – **D** – **C** – **B** – **A** – **X** **(1)** Lattice energy = −2052.4/−2052/−2050 (kJ mol^{-1}) **(1)** Correct answer, with or without working scores 2 Correct method with incorrect final answer scores (1) +2052.4/+2052/+2050 (kJ mol^{-1}) **(1)**	335.2 / −335.2 / −162.5 score **(0)** overall	**2**

Question Number	Acceptable Answers	Reject	Mark
4(c)(iv)	**1 mark:** Bonding is (almost) 100% ionic / bonding is (almost) purely ionic /there is no covalent character / little covalent character **(1)** **2nd mark:** (Chloride) **ion(s)** are not polarized / (both) ions are spherical / charge density of Ba^{2+} too low (to polarize anion) **(1)** **ALLOW** 'Very little distortion of (electron) cloud by Ba^{2+} ion' / 'Very little polarization of chloride (ion)'	**Just** "no polarization is taking place" / "no polarization of the bond" / "little distortion from electric cloud" / "barium and chlorine are not easy to polarize" / **just** "not much distortion" / use of **Ba** or **Cl** (as implies atoms)	**2**

Total for Question 4 = 18 marks