Hess's Law

Mark Scheme 1

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	The Core Principles of Chemistry
Sub Topic	Hess's Law
Booklet	Mark Scheme 1

Time Allowed: **76 minutes**

Score: **/63**

Percentage: **/100**

Grade Boundaries:

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

Question Number	Correct Answer	Reject	Mark
1	A		1
	Incorrect Answers: B – The enthalpy changes are added and not subtracted C - The enthalpy changes are incorrectly doubled D- T enthalpy changes are doubled and added both incorrectly		

Question Number	Correct Answer	Reject	Mark
2	C		**1**

Question Number	Correct Answer	Reject	Mark
3	B		**1**

Question Number	Correct Answer	Reject	Mark
4(a)	C		**1**

Question Number	Correct Answer	Reject	Mark
4(b)	D		**1**

Question Number	Correct Answer	Reject	Mark
4(c)	C		**1**

Question Number	Correct Answer	Reject	Mark
5	C		**1**

Question Number	Correct Answer	Mark
6	A	**1**

Question Number	Correct Answer	Mark
7	B	**1**

Question Number	Correct Answer	Mark
8	B	**1**

Question Number	Correct Answer	Mark
9	D	**1**

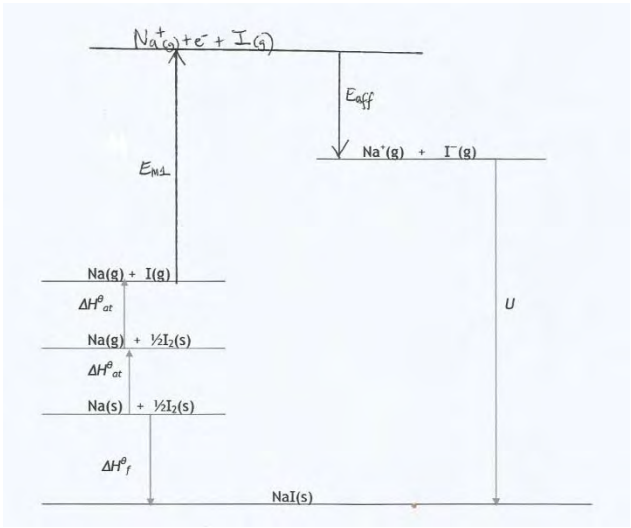
Question Number	Correct Answer	Mark
10	B	**1**

Question Number	Correct Answer	Mark
11	A	**1**

Question Number	Correct Answer	Reject	Mark
12	B		1

Question Number	Correct Answer	Reject	Mark
13	B		1

Question Number	Correct Answer	Reject	Mark
14	A		1

Question Number	Acceptable Answers	Reject	Mark
15(a)	Diagram similar to:  **Marking point 1** Arrow upwards for first ionisation energy of sodium and correct label on arrow (from correct entities) (1) **Marking point 2** Arrow downwards for electron affinity of iodine and correct label on arrow (from correct entities) (1) **Marking point 3** Correct entities with states (on horizontal line) Ignore missing electron (1) ALLOW Numerical values for labels on arrows Recognisable symbols for labels on arrows, such as ΔH_{IE}, ΔH_{EA}		3

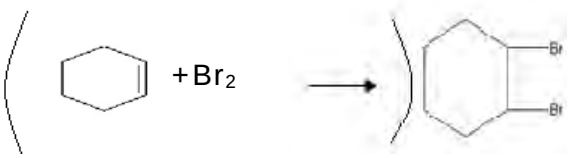
Question Number	Acceptable Answers	Reject	Mark
15 (b)	(LE = 107+107+496+288-295=) —703 kJ mol^{-1}		1

Question Number	Acceptable Answers	Reject	Mark
15 (c)	Energy is required to break bonds (1) In sodium these are metallic bonds/(electrostatic) attractions between metallic cations and the sea of delocalised electrons (1) In iodine these are covalent bonds (between the iodine atoms and London forces) (1) Mark independently		3

Question Number	Acceptable Answers	Reject	Mark
15(d)(i)	(Sodium iodide has) some covalent character / some covalency/some polarisation ALLOW the electron cloud of the iodide ion is distorted Ignore references to NaI being not 100% ionic/ NaI being just 'covalent' (1) which results in stronger bonding (than purely ionic) (1) Ignore References to standard conditions/expt. error		2

Question Number	Acceptable Answers	Reject	Mark
15(d)(ii)	Diagram with distorted electron density cloud towards the sodium ion Example  Ignore the size difference between the ions	Iodine contour line overlaps with sodium contour line	1

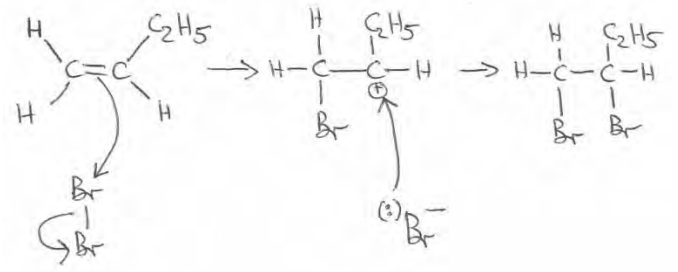
(Total for question 15 = 10 marks)

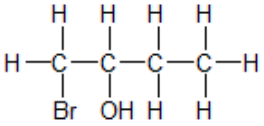
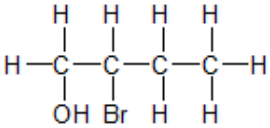
Question Number	Acceptable Answers	Reject	Mark
16(a)(i)	 IGNORE bond angles, bond lengths, bond orientations	+ 2	1

Question Number	Acceptable Answers	Reject	Mark
16(a)(ii)	From red-brown / red / brown to colourless	Clear/white Orange/yellow/ Orange-brown	1

Question Number	Acceptable Answers	Reject	Mark
16(b)(i)	(Bonds broken =) 612 + 193 = (+)805 (Bonds made=) 347 + (290x2)=(-) 927 (1) Enthalpy of reaction =(805 — 927=) —122 (kJ mol^{-1}) Correct answer with no working scores two marks ALLOW (All bonds broken=)+4803 (All bonds made =)-4925 (1) Enthalpy of reaction = (+4803 – 4925=) -122 (kJ mol^{-1}) (1) Award one mark for (+) 122 (kJ mol^{-1}) Award one mark for a correct subtraction using one of the correct values above, example 4538 – 4925 = –387 (kJ mol^{-1})		2

Question Number	Acceptable Answers	Reject	Mark
16(b)(ii)	Bond enthalpies are for gaseous compounds **and** bromine is a liquid / 1,2 dibromobutane is a liquid IGNORE Reference to just ‘different states’		1

Question Number	Acceptable Answers	Reject	Mark
16(b)(iii)	Mechanism drawn similar to  **Marking point 1** Curly arrow from double bond to Br **and** curly arrow from Br-Br bond to the Br (dipoles not required) (1) **Marking point 2** Correct carbocation structure (1) **Marking point 3** Curly arrow from anywhere on the bromide ion (including the minus sign) towards the carbocation **and** the correct product ALLOW TE on primary carbocation (1) Note the bromide ion must have a full negative charge but the lone pair of electrons need not be shown	Incorrect dipole $^{\delta-}$Br	3

Question Number	Acceptable Answers	Reject	Mark
16(b)(iv)	1-bromobutan-2-ol / $CH_3CH_2CHOHCH_2Br$/  ALLOW 2-bromobutan-1-ol / $CH_3CH_2CHBrCH_2OH$/  ALLOW 2-bromo-1-butanol ALLOW skeletal or structural formulae Penalise contradictory names/formulae	Missing H's	1

TOTAL FOR QUESTION 16 = 9 MARKS

Question Number	Acceptable Answers	Reject	Mark
17(a)(i)	ΔH_2 **ALLOW** ΔH_2 = ……		**1**

Question Number	Acceptable Answers	Reject	Mark
17(a)(ii)	ΔH_5 **ALLOW** ΔH_5 = ……	$\frac{\Delta H_5}{2}$	**1**

Question Number	Acceptable Answers	Reject	Mark
17(a)(iii)	$\frac{\Delta H_6}{2}$ OR ΔH_6 / 2 OR $\Delta H_6 \div 2$ OR 0.5 ΔH_6	ΔH_6	**1**

Question Number	Acceptable Answers	Reject	Mark
17(a)(iv)	ΔH_1 **ALLOW** ΔH_1 = ……	ΔH_7	**1**

Question Number	Acceptable Answers	Reject	Mark
17(b)(i)	(The energy change / enthalpy change that accompanies / energy released / enthalpy released) the formation of **one mole** of a(n ionic) compound **(1)** ALLOW as alternative for compound: lattice /crystal / substance / solid / product from its **gaseous ions** **(1)** *NOTE* 'one mole of gaseous ions' scores max **(1)** (ie 2nd mark only available) *IGNORE* References to 'constituent elements' References to 'standard conditions' **ALTERNATIVE RESPONSE** If no mark(s) already awarded from above, can answer by giving:- energy change / enthalpy change **per mole** **(1)** $Sr^{2+}(g) + 2Cl^{-}(g) \rightarrow SrCl_2(s)$ **ALLOW** Any correct 'generic' equation with state symbols included **(1)**	'Energy / enthalpy **required' / 'used'** 'molecule' **no 1st mark** 'gaseous atoms' **no 2nd mark**	**2**

Question Number	Acceptable Answers	Reject	Mark
17(b)(ii)	[FIRST, check the answer on the answer line IF answer = **—2153** (kJ mol^{-1}) then award **(2)** marks, with or without working] **1st Mark:** $\Delta H_1 = \Delta H_2 + \Delta H_3 + \Delta H_4 + \Delta H_5 + \Delta H_6 + \Delta H_7$ OR $\Delta H_7 = \Delta H_1 - [\Delta H_2 + \Delta H_3 + \Delta H_4 + \Delta H_5 + \Delta H_6]$ OR $\Delta H_7 = -829 - [164 + 550 + 1064 + (122 \times 2) + (2 \times -349)]$ **(1)** **2nd Mark:** $\Delta H_7 = -2153$ (kJ mol^{-1}) **(1)** **NOTE:** **The following answers score (1) mark with or without working** **+**2153 (kJ mol^{-1}) −2031 (kJ mol^{-1}) −2502 (kJ mol^{-1}) −2380 (kJ mol^{-1}) **NO OTHER TEs are allowed on an incorrect expression involving** ΔH_7		**2**

Question Number	Acceptable Answers	Reject	Mark
17*(c)	(Lattice energy of MgF_2 more exothermic than that of NaF because) **1st mark:** Mg^{2+} is smaller (than Na^+) **ALLOW** "Magnesium / Mg is smaller (than sodium / Na)" **(1)** **2nd mark:** Mg^{2+} higher charge / higher charge density (than Na^+) **ALLOW** Any reference to Mg^{2+} **and** Na^+ in answer for the 2nd mark, unless nuclear charge mentioned **(1)** **3rd mark:** (So electrostatic forces of) **attraction** between **ions** stronger in MgF_2 (than in NaF) **ALLOW** Strong**er** ionic bonds in MgF_2 / strong**er** ionic bonding in MgF_2 **(1)** OR reverse arguments	**No 1st mark** if only mention Mg **atom** or **atomic** radius "Mg^{2+} higher **nuclear** charge"	**3**

(Total for Question 17 = 11 marks)

Question Number	Acceptable Answers	Reject	Mark
18(a)	C_nH_{2n} ALLOW Letters other than *n*		**1**

ALLOW: (partially) displayed or skeletal formulae throughout **Q18(b)**
IGNORE: additional incorrect non-organic products

Question Number	Acceptable Answers	Reject	Mark
18(b)(i)	CH_3CH_3	C_2H_6	**1**

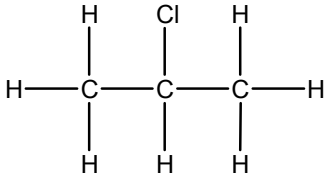
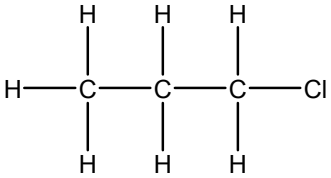
Question Number	Acceptable Answers	Reject	Mark
18(b)(ii)	$ClCH_2CH_2Cl$ / CH_2ClCH_2Cl	$C_2H_4Cl_2$	**1**

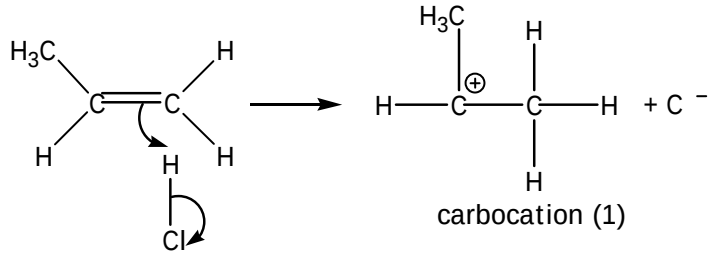
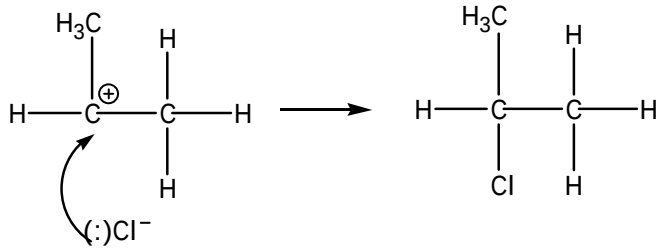
ONLY PENALISE <u>ONCE ONLY</u> in (b)(iii) & (b)(iv) THE CONNECTIVITY BETWEEN C and OH if CLEARLY a C to H covalent bond has been drawn

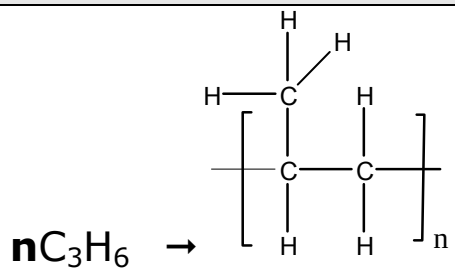
Question Number	Acceptable Answers	Reject	Mark
18(b)(iii)	CH_2CH_2OH / CH_2OHCH_2OH	$C_2H_6O_2$ / **OH**CH_2CH_2OH	**1**

Question Number	Acceptable Answers	Reject	Mark
18(b)(iv)	$HOCH_2CH_2Br$ / CH_2OHCH_2Br	$BrCH_2CH_2Br$ / C_2H_5OBr / $C_2H_4Br_2$	**1**

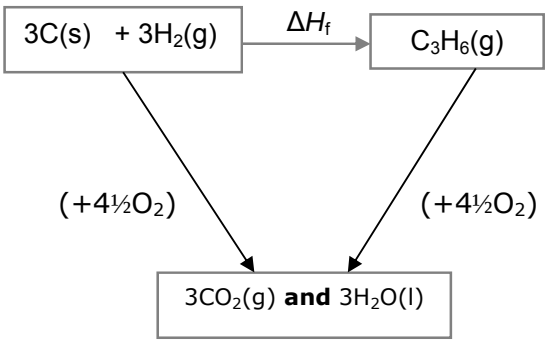
PENALISE USE OF Br instead of Cl once only in parts (c)(i) & (c)(ii)
PENALISE missing H atoms from displayed formulae once only in parts (c)(i) & (c)(ii)

Question Number	Acceptable Answers	Reject	Mark
18(c)(i)	 (Major product) **(1)**  (Minor product) **(1)** Both DISPLAYED structures, with all bonds and atoms shown but in the wrong boxes scores **(1)** **PENALISE** CH_3 not fully displayed **ONCE** only **So** $CH_3CH(Cl)CH_3$ and $CH_3CH_2CH_2Cl$ scores **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
18(c)(ii)	 both arrows (1) carbocation (1)  attack of chloride ion (1) **1st mark:** Curly arrow from C=C to H (in H—Cl) **AND** curly arrow from bond in H—Cl to the Cl (dipole not reqd) Curly arrows must start from the bonds **NOT** the atoms **(1)** **2nd mark:** Structure of correct secondary carbocation **(1)** **3rd mark:** Curly arrow from anywhere on the chloride ion (including the minus sign) towards the C+ on the carbocation **(1)** **NOTE:** The chloride ion must have a full negative charge, but the lone pair of electrons on the Cl^- need not be shown **ALLOW:** TE on major product given in (c)(i) Skeletal formulae can be used **Mark the three points independently**	**Full +** and **-** charges on HCl **Incorrect** polarity on HCl Extra / spare bond dangling from the C+ carbon δ- on chloride ion instead of Cl^-	**3**

Question Number	Acceptable Answers	Reject	Mark
18(d)(i)	 $\mathbf{n}C_3H_6 \rightarrow$ TWO 'n' in the equation and a correct formula (molecular or structural) for propene on the left-hand side of the equation **(1)** **One** correct repeating unit, with the methyl branch shown **(1)** **ALLOW** CH_3 fully displayed or just as CH_3 **BOTH** continuation bonds (with or without bracket shown) **(1)** If C=C bond left in polymer on right-hand side, then max (1) **Mark the three points independently**		**3**

Question Number	Acceptable Answers	Reject	Mark
18(d)(ii)	Non-biodegradable IGNORE References to toxicity of poly(propene) / flammability IGNORE Litter / pollution / waste of resources / costs **ALLOW** People are reluctant to recycle OR Harmful to marine life / harmful to wildlife OR References to 'landfill' OR References to 'incineration' producing toxic fumes/toxic gases / CO_2 / Greenhouse gases OR References to use of **energy**/**fuel** used in transport (of waste) OR It takes a long time to degrade		**1**

Question Number	Acceptable Answers	Reject	Mark
18(e)(i)	 Both arrows in the correct direction **AND** $3CO_2$ **and** $3H_2O$ in lowest box IGNORE state symbols, even if incorrect IGNORE extra O_2 molecules in box or alongside arrows		**1**

Question Number	Acceptable Answers	Reject	Mark
18(e)(ii)	**1st mark** (−394 x 3) + (−286 x 3) OR = −2040 (kJ mol^{-1}) **(1)** **2nd mark:** ΔH_f = −2040 − (−2058) = (+)18 (kJ mol^{-1}) **(1)** **NOTE:** **The following answers score (1) mark** **with or without working** **−**18 (kJ mol^{-1}) (+)1378 (kJ mol^{-1}) (+)806 (kJ mol^{-1}) (+)590 (kJ mol^{-1}) −4098 (kJ mol^{-1}) IGNORE units even if incorrect		**2**

(Total for Question 18 = 17 marks