Born-Haber Cycles

Mark Scheme 6

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Chemical Energetics
Sub-Topic	Born-Haber Cycles
Paper Type	Theory
Booklet	Mark Scheme 6

Time Allowed:	**77 minutes**
Score:	**/64**
Percentage:	**/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 **(a** **(i)** *either* burn *or* shine light/uv on mixture of H_2 + Cl_2 *but* NOT heat [1]

(ii) red/orange/brown colour of bromine decolourises/disappears
steamy/misty/white fumes produced
container gets warm/hot [2]

(iii) H-H = 436   Cl-Cl = 244   H-Cl = 431

$\Delta H = 436 + 244 - 2(431) = -182\ \text{kJ mol}^{-1}$ [2]

H-H = 4   Br-Br = 193   H-Br = 3

$\Delta H = 436 + 193 - 2(366) = -103\ \text{kJ mol}^{-1}$ [2]

(iv) H-Br bond is weaker than the H-Cl bond – allow converse. [1]
[8]

(b) **(i)** light [1]

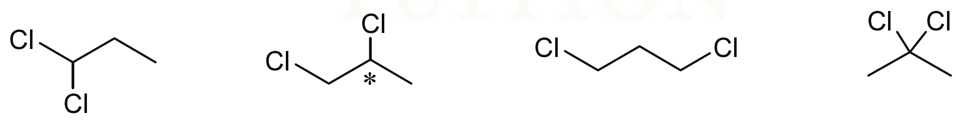
(ii) bonds broken = C-H & I-I = 410 + 151 = 561
bonds made = C-I & H-I = 240 + 299 = 539
ΔH = 551 – 539 = +22 kJ mol^{-1} [2]

(iii) The overall reaction is endothermic *or* no strong bonds/only weak bonds are formed *or* high E_{act} [1]
[4]

(c) **(i)** homolytic fission is the breaking of a bond to form (two) radicals/neutral species/ odd-electron species [1]

(ii) $\bullet CH_2Cl$ [1]
the C-Br bond is the weakest or needs least energy to break/breaks most easily [1]
[3]

(d)



4 structures: [2]
2 or 3 structures: [1]

Correct chiral atom identified [1]
[3]

[Total: 18]

2 **(a** **(i)** a compound which contains **only** carbon and hydrogen (1)

(ii) separation of compounds by their boiling points (1) [2]

(b) **(i)** high temperature **and** high pressure (1)

high temperature **and** catalyst (1)

(ii) $C_{11}H_{24} \rightarrow C_5H_{12} + C_6H_{12}$ **or**

$C_{11}H_{24} \rightarrow C_5H_{12} + 2C_3H_6$ **or**

$C_{11}H_{24} \rightarrow C_5H_{12} + 3C_2H_4$ (1) [3]

(c)

$CH_3CH_2CH_2CH_2CH_3$	$CH_3CH_2CHCH_3$ | CH_3	CH_3 | CH_3CCH_3 | CH_3
isomer **B**	isomer **C**	isomer **D**
(1)	(1)	(1)

(ii) the straight chain isomer (isomer **B** above) (1)

it has the greatest van der Waals' forces (1)

because unbranched molecules have greater area of contact/
can pack more closely together (1) [6]

(d) enthalpy change when 1 mol of a substance (1)

is burnt in an excess of oxygen/air under standard conditions
or is completely combusted under standard conditions (1) [2]

(e) **(i)** heat released = m c δT = 200 x 4.18 x 27.5 (1)

= 22990 J = 23.0 kJ (1)

(ii) 23.0 kJ produced from 0.47 g of **E**

2059 kJ produced from $\frac{0.47 \times 2059}{23.0}$ g of **E** (1)

= 42.08 g of **E** (1)

allow ecf in **(i)** or **(ii)** on candidate's expressions [4]

(f) C_3H_6 = 42

E is C_3H_6

for ecf, **E** must be unsaturated and be no larger than C_5 (1)

[Total: 18]

3 **(a (i)** $P_2O_5 + 3H_2O \rightarrow 2H_3PO_4$ (or similar) or $P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$ (1)
$SO_2 + H_2O \rightarrow H_2SO_3$ (1)

(ii) $2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$ (1)

(iii) $2ClO_2 + 2NaOH \rightarrow NaClO_2 + NaClO_3 + H_2O$ or ionic eqn (1) **[4]**

(b) (i) $2CH_4 + C_2H_6 + H_2S + 9O_2 \rightarrow 4CO_2 + SO_2 + 8H_2O$
Formulae (1), balanced (1)

(ii) (The SO_2 produced) causes acid rain (1)
or consequence of acid rain – defoliation etc. – or respiratory problem

(iii) 1000 dm^3 contains 50 dm^3 of H_2S
this is 50/24 (= **2.083** moles) (1)
M_r(ethanolamine) = 24 + 7 + 14 + 16 = **61**
therefore mass = 2.083 × 61 = **127(.1)**g (1) (or ecf)

(iv) acid-base (1)

(v) $\Delta H = \Delta H_f(\text{rhs}) - \Delta H_f(\text{lhs})$
= {(3 × 11 – 2 × 242)}{–}{(2 × –21 – 297)} –1 for each { } in which there is an error
= –451 + 339
= –112 (kJ mol^{-1}) (2) **[8]**

[Total: 12]

4 **(a** **(i)**

	CH_4	+	Cl_2	$\rightarrow$	CH_3Cl	+	HCl	
$\Delta H_f^\ominus$	–75		0		–82		–92	(1)

$\Delta H^\ominus_{reaction}$ = –82 + (–92) – (–75)
= –99 kJ mol^{-1} (1)

(ii)

	CH_4	+	I_2	$\rightarrow$	CH_3I	+	HI	
broken	C–H		I–I	made	C–I		H–I	
	410		151		240		299	(1)

$\Delta H^\ominus_{reaction}$ = –240 + (–299) + 410 + 151
= +22 kJ mol^{-1} (1)

(iii) activation energy is too great (1) [5]

(b) **(** initiation
Cl_2 + uvl $\rightarrow$ 2Cl (1)
propagation (1)

$CH_4 + Cl \rightarrow CH_3 + HCl$
$CH_3 + Cl_2 \rightarrow CH_3Cl + Cl$ both needed (1)

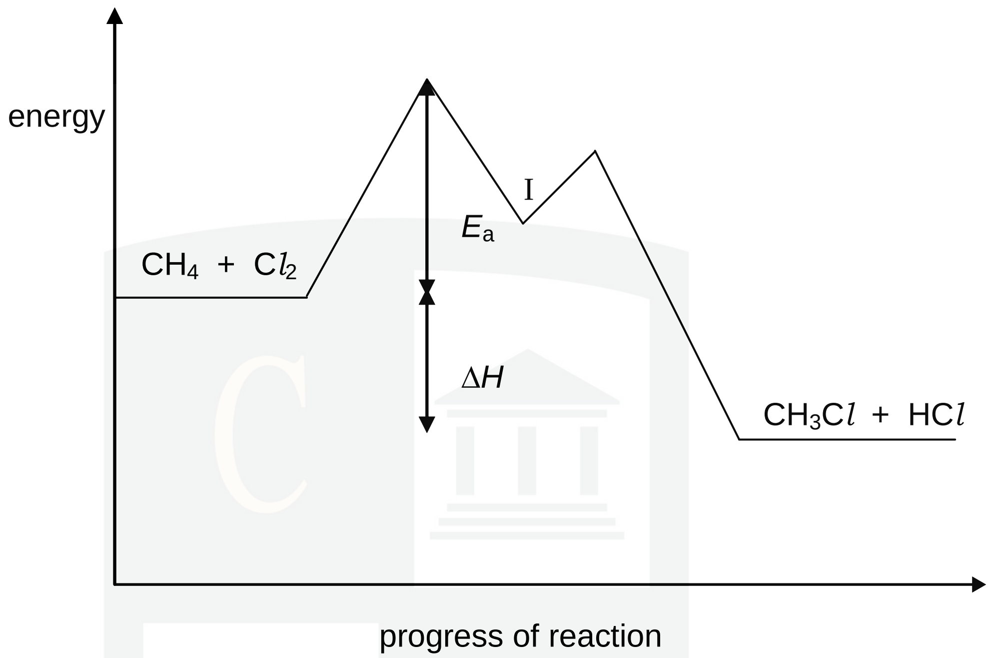
termination (1)

$CH_3 + CH_3 \rightarrow C_2H_6$ **or**
$CH_3 + Cl \rightarrow CH_3Cl$ **or**

$Cl + Cl \rightarrow Cl_2$ (1)

(ii) CH_3/methyl radical (1) [7]

(c)



correct placement of 16 kJ (
correct placement of –99 kJ (allow ecf on wrong calculation in **(a) (i)**) (1
intermediate clearly shown at I (1)
correct 'double peak' shape (1)
second peak lower than first (1) [5]

[Total: max 16]