Born-Haber Cycles

Mark Scheme 4

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Chemical Energetics
Sub-Topic	Born-Haber Cycles
Paper Type	Theory
Booklet	Mark Scheme 4

Time Allowed: **66 minutes**

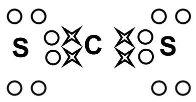
Score: **/55**

Percentage: **/100**

Grade Boundaries:

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

1 (a (i)



S atom has 6 **and C** atom has 4 electrons (1)

S=C double bonds (4 electrons) clearly shown (1)

(ii) linear **and** 180° (1)

(b) ($CS_2 + 3O_2 \rightarrow CO_2 + 2SO_2$ (1)

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

is burnt in an excess of oxygen/air

or is completely combusted

under standard conditions (1) [3]

(c)

	CS_2	+	$3O_2$	$\rightarrow$	CO_2	+	$2SO_2$
$\Delta H_f^{\ominus}$/kJ mol^{-1}	x				–395		2(–298)

(1)

$\Delta H_{reaction} = -395 + 2(-298) - x = -1110\ \text{kJ mol}^{-1}$ (1)

gives $x = -395 + (-596) + 1110 = +119\ \text{kJ mol}^{-1}$ (1) [3]

(d) ($CS_2 + 2NO \rightarrow CO_2 + 2S + N_2$

or

$CS_2 + 2NO \rightarrow CO + 2S + N_2O$

correct products (1)

correct equation (1)

(ii) from –2 to 0 **both** required (1) [3]

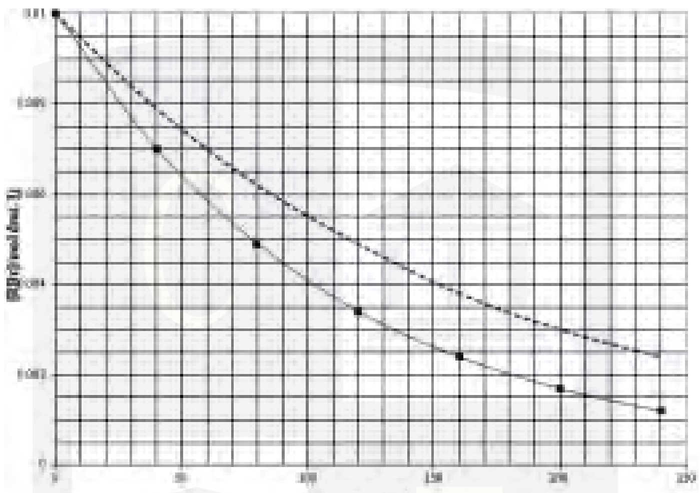
[Total: 12]

2 **(a** **(i)** RBr + OH^- $\longrightarrow$ ROH+ Br^- [1]

(ii) nucleophilic substitution [1]

[2]

(b)



plotting of all points (plotted to within ½ small square) [1]

good line of best fit [1]

(ii) $t_{½}$ = 118 min or 79 min (± 5 min)
or
construction lines for two half-lives **and** mention that half-life is constant
or
calculate the ratio of two rates at two different concentrations [1]

(iii) either ratio of initial rates (slopes)
or
ratio of $t_{½}$
or
ratio of times for [RBr] to fall to the same level: all should be = 1.5 [1]

therefore reaction is first order w.r.t. [OH^-] [1]

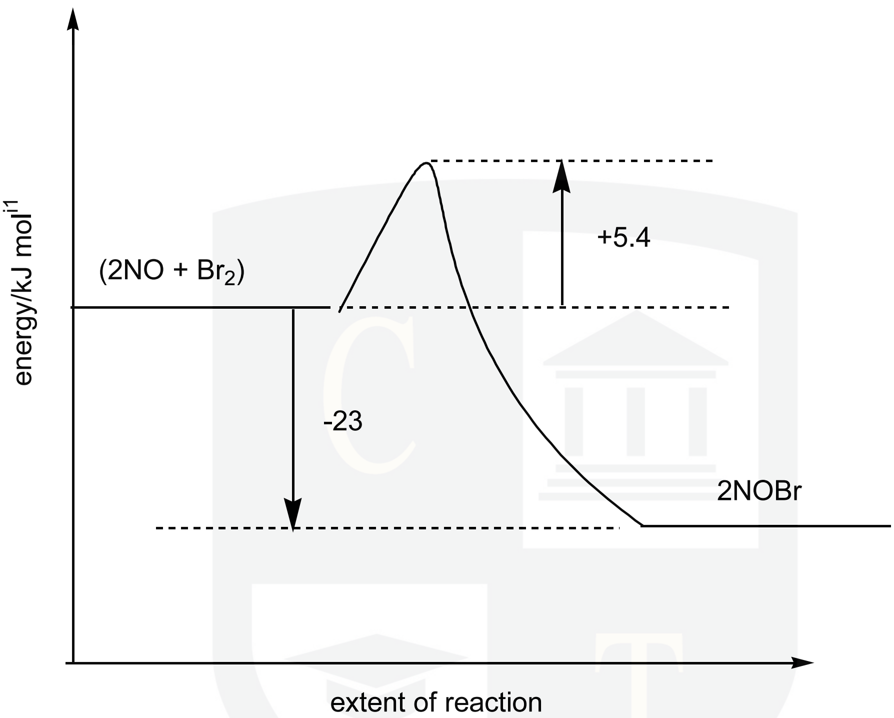
(iv) rate = k [RBr] [OH^-] [1

initial rate = 0.01 / 185 = 5.4×10^{-5} (mol dm^{-3} min^{-1}) [1

k = 5.4×10^{-5} / (0.01 × 0.1) = 0.054 (mol^{-1} dm^3 min^{-1}) [1

[8 max 7]

(c)



four marking points: one activation "hump"
2NOBr (not just NOBr)
Δ*H* labelled correctly (arrow down, or double headed, or just a line)
E_a labelled correctly (arrow up, or double headed, or just a line)
all four points [2]
three or two points [1]
[2]

[Total: 11]

3 **(a (i)** alkanes **or** paraffins **not** hydrocarbons (1)

(ii) $C_9H_{20} + \mathbf{14}O_2 \rightarrow \mathbf{9}CO_2 + \mathbf{10}H_2O$ (1 [2]

(b) (carbon (1)
carbon monoxide (1)
(names required)

(ii) CO is toxic **or** affects or combines with haemoglobin
or carbon causes respiratory problems (1)

(iii) $C_{14}H_{30} + \mathbf{15}O_2 \rightarrow \mathbf{28}C + \mathbf{30}H_2O$ **or**

$\mathbf{2}C_{14}H_{30} + \mathbf{29}O_2 \rightarrow \mathbf{28}CO + \mathbf{30}H_2O$

or other balanced equations such as

$C_{14}H_{30} + \mathbf{11}O_2 \rightarrow \mathbf{7}C + 7CO + \mathbf{15}H_20$

$C_{14}H_{30} + \mathbf{18}O_2 \rightarrow \mathbf{7}CO + 7CO_2 + \mathbf{15}H_20$ (1 [4]

(c) 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]

(d) working **must** be shown

(i) heat released = m c δT = 250 × 4.18 × 34.6 (1)
= 36157 J = 36.2 kJ (1)

(ii) M_r of $C_{14}H_{30}$ = 198 (1)
mass of $C_{14}H_{30}$ = 1.00 × 0.763 = 0.763 g (1)
0.763 g of $C_{14}H_{30}$ produce 36.2 kJ
198 g of $C_{14}H_{30}$ produce $\frac{36.2 \times 198}{0.763}$
= 9394 kJ mol^{-1} (1) [5]

[Total: 13]

4 **(a** (the energy change) when 1 mol of bonds [1]
is broken in the gas phase [1]

[2]

(b) **(i)** (C-X bond energy) decreases/becomes weaker (from F to I) [1

due to bond becoming longer/not such efficient orbital overlap [1]

(ii) (as the bond energy of C-X decreases) the halogenalkanes become more reactive
(answer must imply that it is from F to I) [1

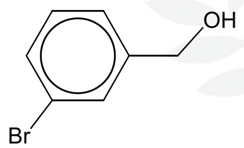
[3]

(c) The C-C*l* bond is weaker than the C-F **<u>and</u>** C-H bonds
or C-C*l* bond (E = 340) **and** C-H (E = 410) [1]

so is (easily) broken to form $Cl^{\bullet}$/C*l* radicals/C*l* atoms
causing the breakdown of O_3 into O_2 [1]

[3]

(d) $Cl\text{-}CH_2CH_2\text{-}CO_2H$ [1]
$HO\text{-}CH_2CH_2CH_2\text{-}Cl$ [1]



[1]

[3]

(e) **(** light/UV/hν *or* 300°C [1

(ii) (free) radical substitution [1]

(iii) ΔH = E(C-H) – E(H-C*l*) = 410 – 431 = **–21** kJ mol^{-1} [1]

(iv) ΔH = E(C-H) – E(H-I) = 410 – 299 = **+111** kJ mol^{-1} ecf [1]

(v) The reaction with iodine is endothermic *or* ΔH is positive *or* requires energy [1]

(vi) $Cl_2 \longrightarrow \mathbf{2Cl^{\bullet}}$ [1]
$CH_3CH_2^{\bullet} + \mathbf{Cl_2} \longrightarrow \mathbf{CH_3CH_2Cl + Cl^{\bullet}}$ [1]
$\mathbf{CH_3CH_2^{\bullet} + Cl^{\bullet}} \longrightarrow CH_3CH_2Cl$ [1]

[8]

[Total: 19]