Cambridge Chemistry Challenge Lower 6th

June 2023

Marking scheme for teachers

(please also read the additional instructions)

	p2	p3	p4	p5	p6	p7	Total
mark	14	9	9	12	14	12	70

Marks available

1(a) (i)

Cl	Sr	Nb	Xe
7	2	5	8

2

(ii) Half mark each. No marks for any numbers >8.

S^{2-}	O^{+}	N^{+}	Tl^{+}	B^{3+}	Na^{-}
8	5	4	2	0	2

3

Half mark each. No marks for any numbers >8.

1(b) Circle the correct answer:

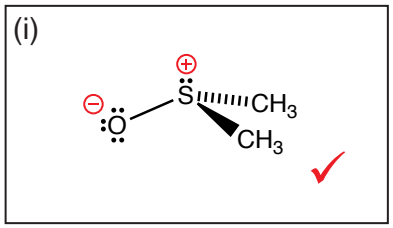
i) just less than +1 ii) +1 exactly

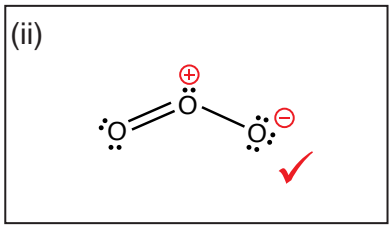
iii) at least +1 iv) just less than +1/3

v) +1/3 exactly vi) at least +1/3 ✓

1

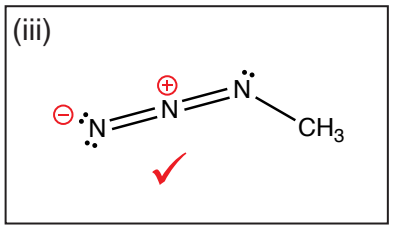
1(c)

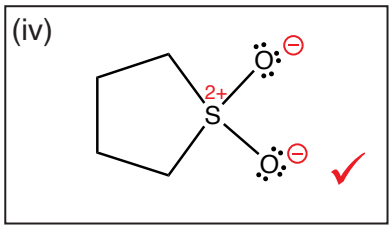
(i) 

(ii) 

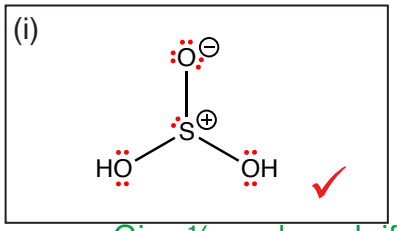
No need to write +1 or –1 if single charges. No partial credit.

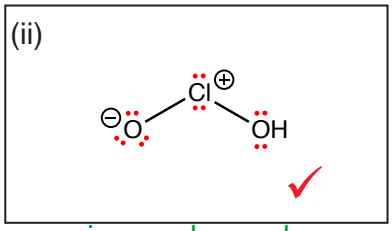
4

(iii) 

(iv) 

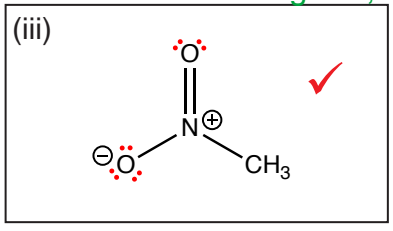
1(d)

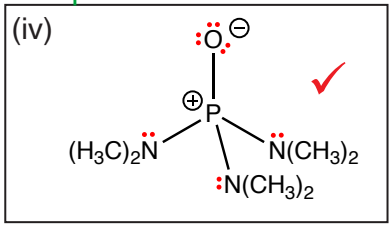
(i) 

(ii) 

Give ½ mark each if only lone pairs on charged atoms are given, but no other partial marks.

4

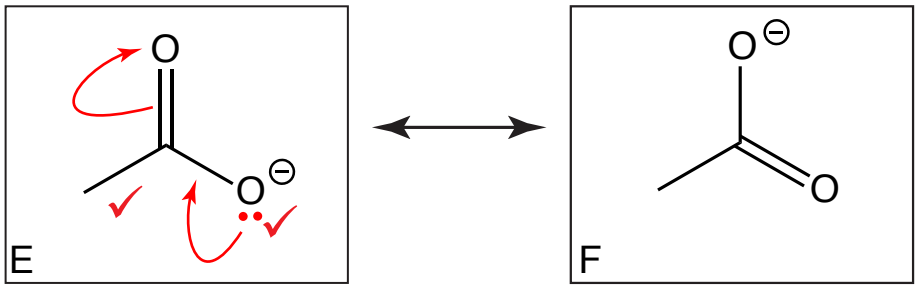
(iii) 

(iv) 

Page total 14

Marks available

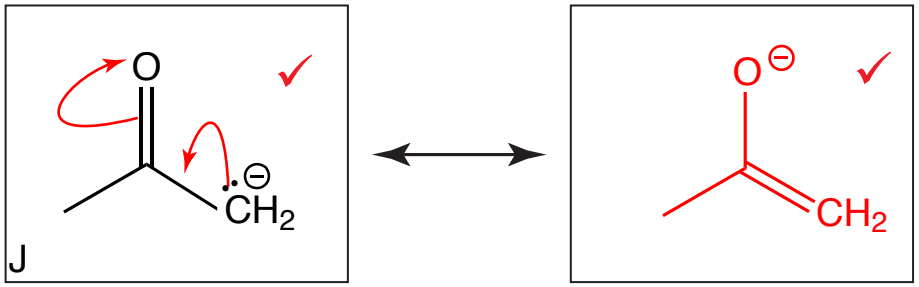
1(e)



2

1 mark for lone pair. 1 mark for BOTH arrows.

1(f) (i)



2

1 mark for correct arrows, 1 mark for correct resonance form with charge on O.

1(f) (ii) Circle one:

Same Stronger **Weaker** 1

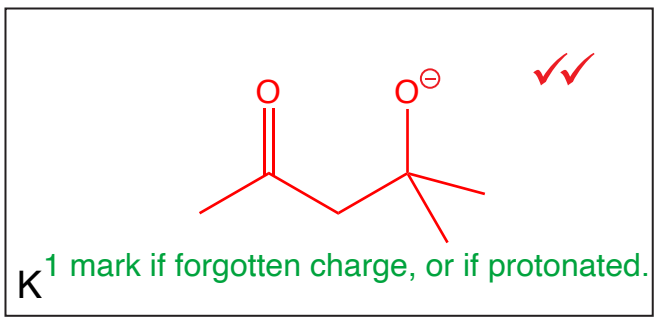
1(f) (iii) Circle one:

Same **Stronger** Weaker 1

1(f) (iv) Circle one:

A **B** C 1

1(f) (v)

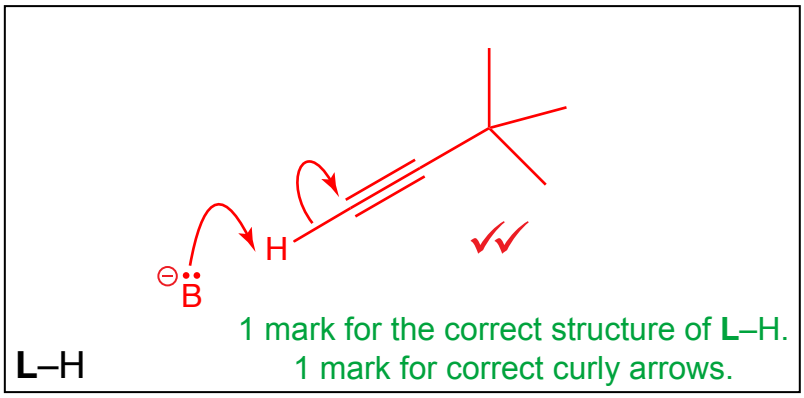


1 mark if forgotten charge, or if protonated. 2

Page total 9

Marks available

1(g) (i)

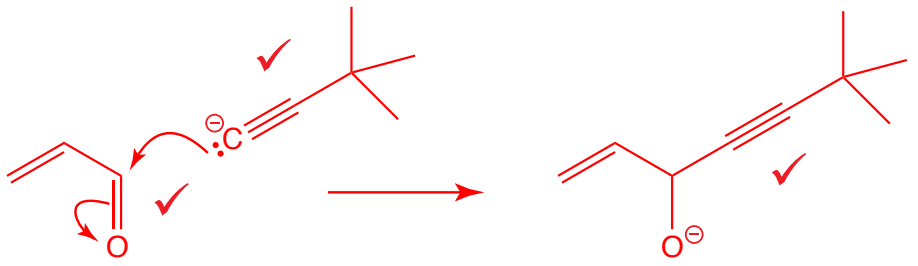


L–H

1 mark for the correct structure of **L**–H.
1 mark for correct curly arrows.

2

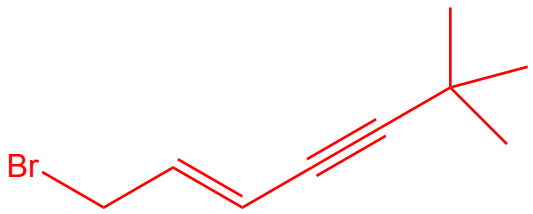
1(g) (ii)



1 mark for the correct structure of $\mathbf{L}^-$.
1 mark for correct curly arrows. 1 mark for correct structure of $\mathbf{Z}^-$.

3

1(g) (iii)

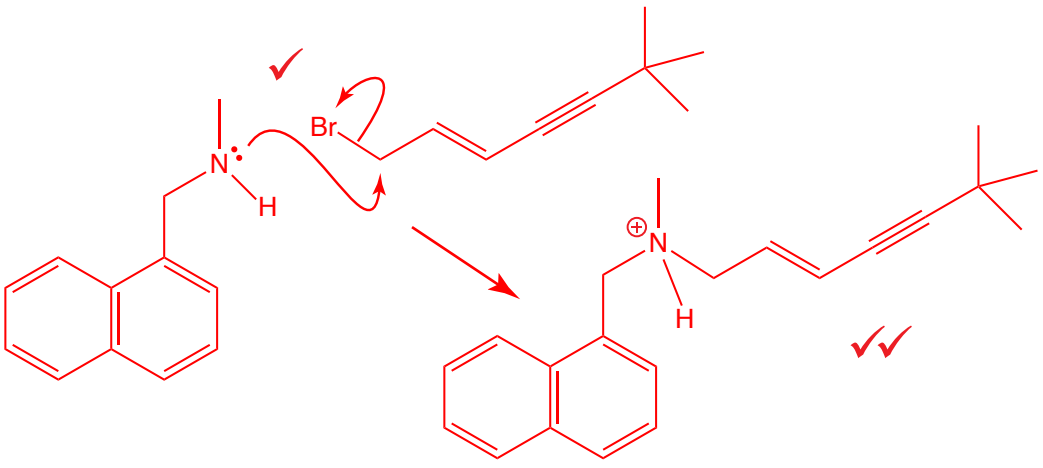


Q

(Do not penalise if cis isomer.)

1

1(g) (iv)



1 mark for curly arrows. 2 marks for final structure if correct,
1 mark if not protonated OR missed charge.
1 mark partial credit for final structure for e.c.f.

3

Page total 9

Marks available

2(a) (i)

$Bi + 3/2\ Cl_2 \longrightarrow BiCl_3$ ✓

(state symbols not required. All times 2 also fine.)

1

2(a) (ii) Circle one:

95°–108° ✓ 108°–110° 110°–119° 119°–121° >121°

1

2(a) (iii)

(If no working on this question, ½ mark each for correct answer)

Bi : O = 89.70g : 10.30 g = (89.70 / 208.98) : (10.30 / 16) mol

= 0.4292 : 0.6438 mol

= 1 : 1.5 = 2 : 3

Formula: Bi_2O_3 ✓ Oxidation state: +3 ✓

2

2(a) (iv)

Maximum oxidation state

+5 ✓

(v)

Formula

BiF_5 ✓

(No marks for BiX_5 or $BiCl_5$ etc. Must be BiF_5)

2

2(b)

isotope thallium-205 ✓✓

(1 for element, 1 for mass)

2

2(c) (i) equation

$Bi(CH_3)_3(l) + 6O_2(g) \longrightarrow ½Bi_2O_3(s) + 3CO_2(g) + 4½H_2O(l)$ ✓✓

(Full marks if all ×2)

2

2(c) (ii)

$[\ 6O_2(g)\ ] + Bi(s) + 3C(s) + 4½H_2(g) \xrightarrow{x} Bi(CH_3)_3(l) \quad [\ + 6O_2(g)\ ]$

½(–574) 3(–394) 4½(–286) –2912

$½Bi_2O_3(s) + 3CO_2(g) + 4½H_2O(l)$

x = ½(–574) – 3(394) – 4½(286) + 2912 kJ mol^{-1} = + 156 kJ mol^{-1}

answer: + 156 kJ mol^{-1} ✓✓

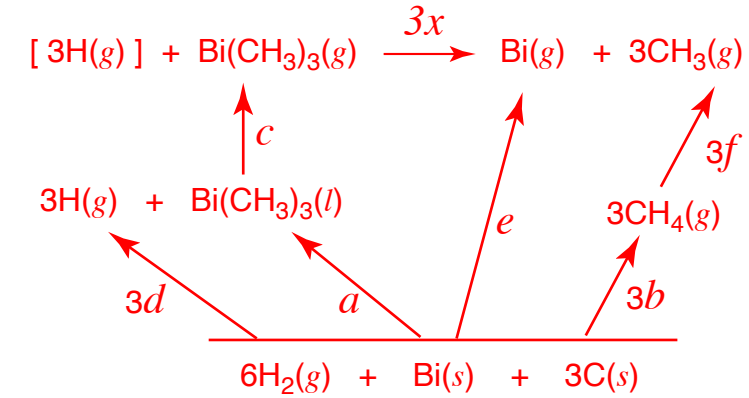
(1 mark for –156. 1½ marks for +312 kJmol^{-1}. No other credit)

2

Page total 12

Marks available

2(d) (i)



$3x = -c - 3d - a + e + 3b + 3f$ kJ mol^{-1}

$x = -1/3a + b - 1/3c - d + 1/3e + f$ kJ mol^{-1}

(1 mark for each number with correct sign.
If ALL numbers correct, but ALL signs wrong, 4 marks.
If ALL numbers correct but ×3, 4 marks.
If ALL numbers ×3 and wrong sign, 2 marks.
No other partial credit.)

$x =$ [−1/3] a [+1] b [−1/3] c [−1] d [+1/3] e [+1] f ✓ ✓ ✓ ✓ ✓ ✓ — 6

2(d) (ii) x = 1/3(−156) −75 − 1/3(35) − (218) +1/3(208) +(429) kJ mol^{-1}

= [−1/3 answer for (c)(ii)] + 194 kJ mol^{-1} = 142 kJ mol^{-1} ✓ — 1

(allow e.c.f. from (c)(ii) but NOT e.c.f. from 2(d)(i) above)

2(e) (i)

number contained in cell = (4 × 1) + (8 × ¼ for ones on edges) = 6 ✓✓ — 2

(no partial credit)

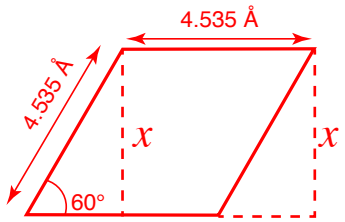
2(e) (ii)

mass = 6 × RAM(Bi) / N_A = (6 × 208.98 / 6.022 ×10^{23}) g

= 2.08 ×10^{-21} g ✓ — 1

(allow e.c.f. from 2(e)(i))

2(e) (iii)



$\sin 60 = \frac{\sqrt{3}}{2} = \frac{x}{4.535}$

$x = \frac{4.535\sqrt{3}}{2}$ ✓

volume = $\frac{4.535^2\sqrt{3}}{2} \times 11.814$ Å^3

volume = 210.4 Å^3 = 210.4 Å^3 ✓ = 210.4 × 10^{-30} m^3 = 2.104 × 10^{-28} m^3

= 2.104 × 10^{-22} cm^3 ✓ — 3

(allow one 1 mark for correctly converting Å^3 into cm^3)

2(e) (iv)

density = 2.08 ×10^{-21} / 2.104 × 10^{-22} g cm^{-3}

= 9.90 g cm^{-3} ✓ — 1

(no partial credit or e.c.f.)

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Marks available

2(f) (i) $BiCl_3(s) + H_2O(l) \longrightarrow BiOCl(s) + 2HCl(aq)$ ✓ — 1

2(f) (ii) $2BiOCl(s) + 3H_2S(aq) \longrightarrow Bi_2S_3(s)$ ✓ $+ 2H_2O(l) + 2HCl(aq)$ ✓ — 2

(1 mark for correct product formula.
1 mark for correctly balanced equation. Allow ×½)

2(g) (i)

Bi : Cl = 83.48g : 16.52 g = (83.48 / 208.98) : (16.52 / 35.45) mol

= 0.3946 : 0.4660 mol

= 1 : 1.1666 ✓

= 6 : 7

Answer: Bi_6Cl_7 ✓ — 2

2(g) (ii) relative empirical mass = (6 × 208.98) + (7 × 35.45) = 1502.03

number of Bi_6O_7 in unit cell = 6008.12 / 1502.03 = 4

formula for unit cell = $Bi_{24}Cl_{28}$ ✓ — 1

2(g) (iii) $[Bi_2Cl_8]^l$ $[BiCl_5]^m$ (half mark each)

l = (2 × 3) – (8 × 1) = –2 m = 3 – (5 × 1) = –2 — 1

2(g) (iv) to get 28 chlorines must be 1 × $[Bi_2Cl_8]^{2-}$ and 4 × $[BiCl_5]^{2-}$

i.e. $q = 1$ and $r = 4$ ✓

this uses 6 bismuths, so 18 left = 2 × 9, i.e. $p = 9$ ✓

$(Bi_9)_2\ (Bi_2Cl_8)\ (BiCl_5)_4$ — 2

2(g) (v) negative charge = –2 + (4 × –2) = –10

so charge for each of the 2 Bi_9 units must be +5.

$[Bi_9]^{5+}$ ✓ — 1

2(g) (vi) $28\ BiCl_3 + 44\ Bi \longrightarrow 3\ Bi_{24}Cl_{28}$ ✓✓ — 2

(Obvioiusly, full marks if more detailed formula of product.
Allow 1/3 of this. No other partial credit.)

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