Cambridge Chemistry Challenge Lower 6th

June 2020

Marking scheme for teachers

(please also read the additional instructions)

	p2	p3	p4	p5	p6	p7	p8	Total
mark	8	7	7	10	8	11	9	60

Marks available

1(a)

(i) Equation: **[1]**

$15\ CuO\ (s) + C_6H_6\ (g) \longrightarrow 6\ CO_2\ (g) + 3\ H_2O\ (g) + 15\ Cu$ ✓

[Do not penalise lack of state symbols throughout]

(ii) RMM and number of moles: **[1]**

$M_r(C_6H_6) = 6 \times A_r(C) + 6 \times A_r(H) = 6 \times 12.01 + 6 \times 1.008 = 78.108$

Moles (C_6H_6) = mass (C_6H_6)/ $M_r(C_6H_6)$

= 0.0128 moles ✓

(iii) Maximum mass formed: **[1]**

1 mole of benzene will form 3 moles of water.

0.644 mmol of benzene will form 3 x 0.644 = 1.932 mmol water

= 0.001932 mol

mass (H_2O) = moles (H_2O) x $M_r(H_2O)$

= 0.001932 x 18.016

= 0.0348 g or 34.8 mg (3 sig. fig.) ✓

[Penalise sig. figs. once only - 1 mark deduction]

(iv) Volume produced: **[1]**

1 mole of benzene will form 6 moles of carbon dioxide.

0.644 mmol of benzene will form 6 x 0.644 = 3.864 mmol carbon dioxide

= 0.003864 mol

0.003864 moles of carbon dioxide will occupy 0.003864 x 24 dm^3

= 0.0927 dm^3 = 92.7 cm^3 (3 sig. fig.) ✓

1(b)

(i) Equation: **[1]**

$2\ C_6H_6\ (g) + 15\ O_2\ (g) \longrightarrow 12\ CO_2\ (g) + 6\ H_2O\ (g)$ ✓

(ii) Equation: **[1]**

$KOH\ (aq) + CO_2\ (g) \longrightarrow KHCO_3\ (aq)$ ✓

[Or]

$2KOH\ (aq) + CO_2\ (g) \longrightarrow K_2CO_3\ (aq) + H_2O\ (aq)$

(iii) Number of volumes in the reaction mixture: **[1]**

1 volume of benzene will form 6 volumes of carbon dioxide.

2.1 volumes of carbon dioxide will form from 2.1 / 6 = 0.35 volumes of benzene. ✓

(iv) Volumes of O_2 **[1]**

1 volume of benzene reacts with 7.5 volumes of oxygen.

0.35 volumes of benzene will react with 0.35 x 6 = 2.625 volumes of oxygen.

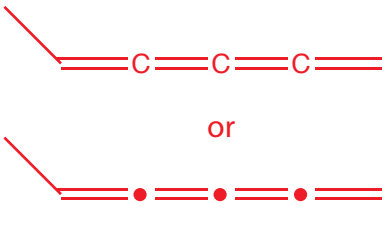
There will be 7.0 - (0.35 + 2.625) = 4.025 volumes of oxygen left.

Page total 8

Marks available

1(c)

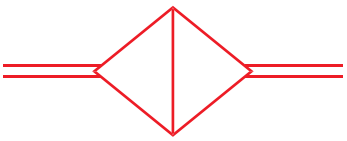
Model **A**



✓

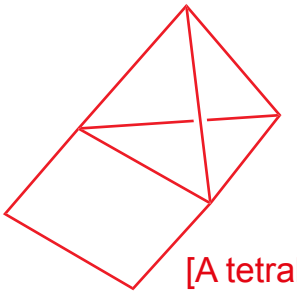
[Do not penalise if geometry is not perfect]

Model **B**



✓

Model **C**



✓

[A tetrahedron with a $-CH_2CH_2-$ unit on one edge]

[3]

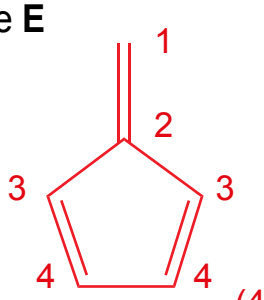
1(d)

Structure **D**

✓

(3 peaks)

Structure **E**

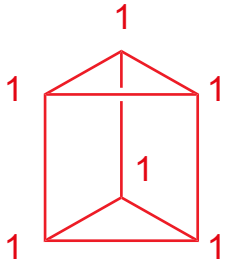


✓

(4 peaks)

[4]

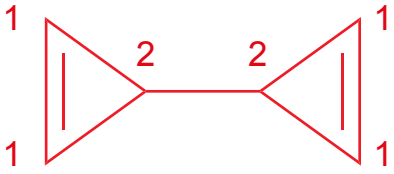
Structure **F**



✓

(1 peak)

Structure **G**



✓

(2 peaks)

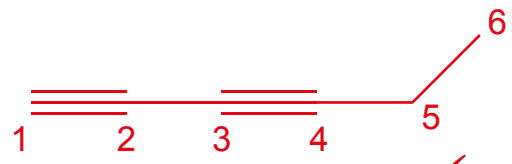
Page total 7

Marks available

1(d)

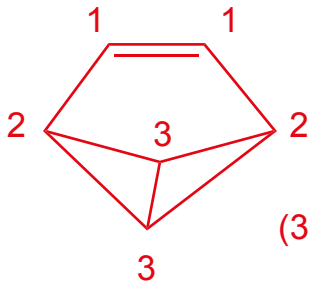
[4]

Structure **H**



(6 peaks) ✓

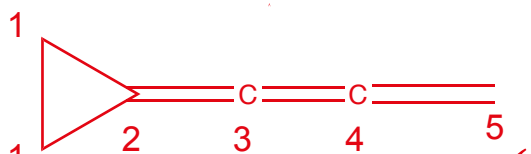
Structure **I**



✓

(3 peaks)

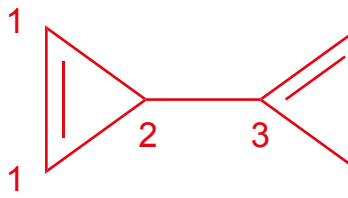
Structure **J**



✓

(5 peaks)

Structure **K**



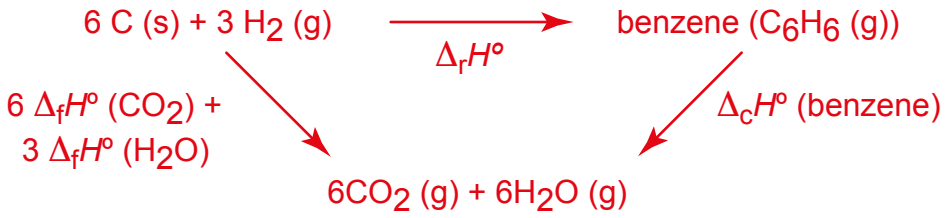
✓

(5 peaks)

1(e)

(i) Standard enthalpy change of formation:

[2]



$\Delta_r H^\circ$ = 6 x $\Delta_f H^\circ$ (CO_2) + 3 $\Delta_f H^\circ$ (H_2O) – $\Delta_c H^\circ$ (benzene) ✓

= (6 x –393.5) + (3 x –285.8) – (–3301)

= 82.60 kJ mol^{-1} (4 sig. fig.) ✓

(ii) Standard enthalpy of combustion:

[1]

Dewar benzene is higher in energy than normal benzene which means more energy will be given out during the combustion.

$\Delta_c H^\circ$ (Dewar benzene) = $\Delta_c H^\circ$ (benzene) – 252 kJ mol^{-1}

= – 3301 – 252 kJ mol^{-1} = – 3553 kJ mol^{-1}

or – 3550 kJ mol^{-1} (3 sig. fig.)

✓

Page total 7

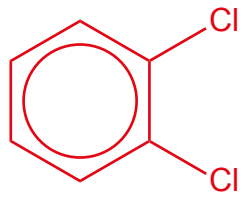
Marks available

10 marks for all of 1(f)

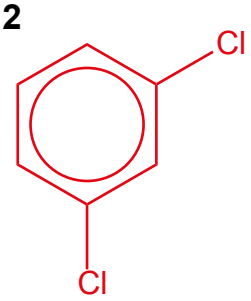
1(f)

(i) Isomers:

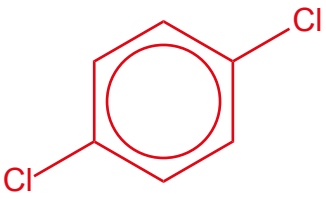
Isomer **1**



Isomer **2**



Isomer 3

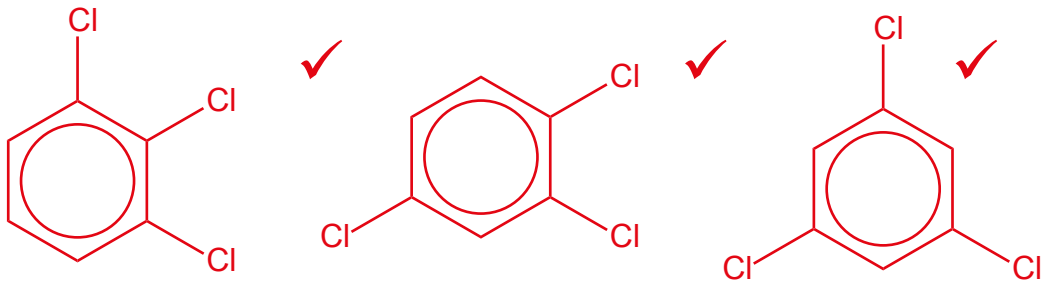


✓

[One mark if all three structures are correct
Half a mark for two correct structures]

1(f)

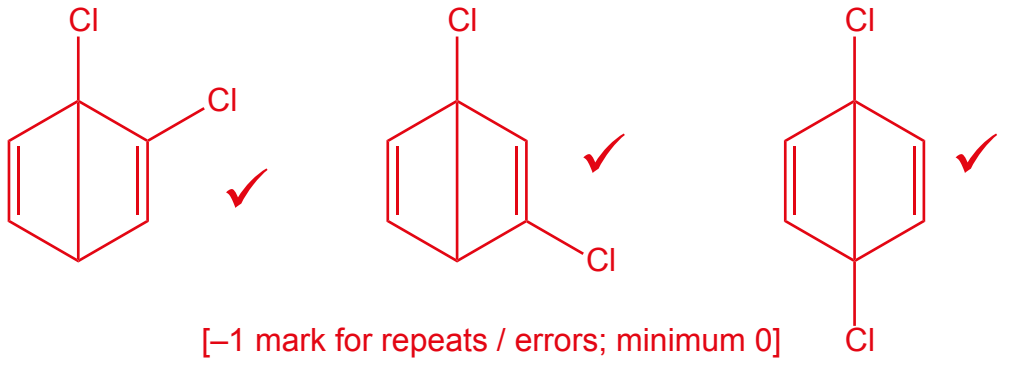
(ii) Isomers:



✓ ✓ ✓

[–1 mark for repeats / errors; minimum 0]

(iii) Isomers:



✓ ✓ ✓

[–1 mark for repeats / errors; minimum 0]

✓ ✓ ✓

Page total 10

Marks available

6 marks for all of 1(g)

1(g)

(i) Same:

L = R; ✓ N = M; ✓ P = S ✓ [–1 for any wrong pair; 0 minimum]

(ii)

N/M is an optical isomer of P/S ✓

[if anything else, 0 marks]

(iii) Total number: ✓

4 structures (L/R, N/M, P/S, and Q)

(iv) Number:

three pairs of isomers of DEWAR benzene

✓

1(h) Number of days : **[2]**

each half-life reduces amount remaining by 0.5. We want amount of remaining Dewar-benzene to be 0.01 of the starting amount. If number of half-lives is n:

$(0.5)^n = 0.01$

taking logs:

$n \log(0.5) = \log(0.01)$

$n = \log(0.01) / \log(0.5) = 2 / \log(2) = 6.644$

Each half-life is 2 days, so 6.644 half-lives are 2 x 6.644

= 13.3 days (or 13 days, 6.9 hours). ✓ ✓

[Give 1 mark if answer is between 13 and 14 days but not exact]

Page total 8

Marks available

2(a)

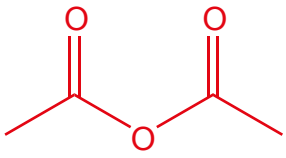
(i) Equation: **[1]**

$Sk(s) + 2HCl(aq) \longrightarrow SkCl_2(aq) + H_2(g)$ ✓

(ii) Oxidised: Sk ✓ [half each] **[1]**

Reduced: Hydrogen (or H^+)

(iii) Structure: **[1]**



✓

(iv) Name: **[1]**

ethanoic acid ✓

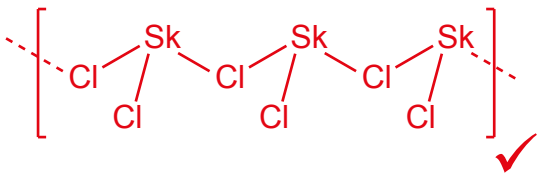
(v) Angle: **[1]**

120° (or just less than) [allow 115° to 120°] ✓

(vi) Angle: **[1]**

90° ✓ (the p orbitals are all at 90° to each other)

(vii) Unit: **[1]**



✓

2(b)

(i) Oxidation states: **[1]**

+2 in $HgCl_2$ and +1 in Hg_2Cl_2 ✓ [half each]

(ii) Equation 1: **[2]**

$SkCl_2 + 2HgCl_2 \longrightarrow SkCl_4 + Hg_2Cl_2$ ✓

Equation 2:

$SkCl_2 + HgCl_2 \longrightarrow SkCl_4 + Hg$ ✓

(iii) Equation: **[1]**

$SkCl_4 + 2H_2O \longrightarrow SkO_2 + 4HCl$ ✓

Page total 11

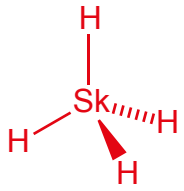
Marks available

2(c)

(i) Equation:

$$SkCl_4 + LiAlH_4 \longrightarrow SkH_4 + LiCl + AlCl_3$$ ✓ [1]

(ii) Structure:



✓

Angle: bond angle 109.5º [half each] [1]

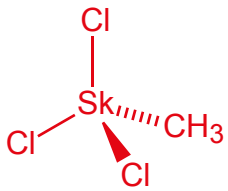
(iii) Equation:

$$SkH_4(g) \longrightarrow Sk(s) + 2H_2(g)$$ ✓ [1]

2(d) Formula: $R_xSkCl_{(4-x)}$ ✓ [1]

2(e)

(i) Structure:

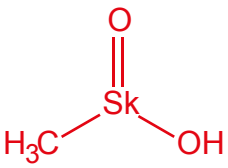


✓ [1]

(ii) Equation:

$$CH_3SkCl_3 + 4NaOH \longrightarrow CH_3SkOONa + 3NaCl + 2H_2O$$ ✓ [1]

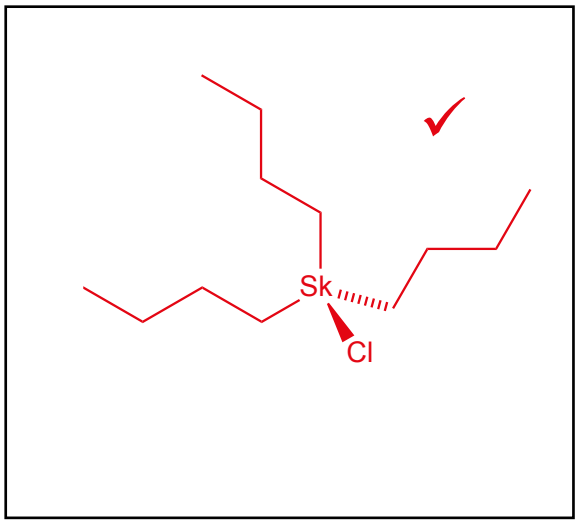
(iii) Structure:



✓ [1]

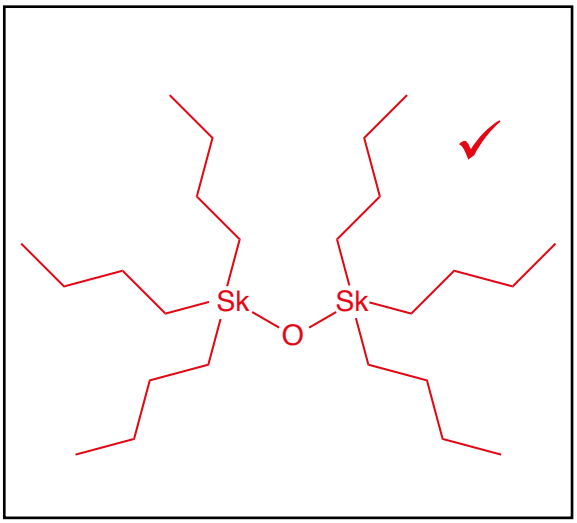
2(f)

(i) Structure:



✓

(ii) Structure:



✓ [2]

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