Cambridge Chemistry Challenge Lower 6th

June 2024

Marking scheme for teachers

(please also read the additional instructions)

	p2	p3	p4	p5	p6	p7	Total
mark	16	13	17	9	10	5	70

Marks available

1(a) (i)

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^3$ ✓

Do not worry about order of $4s^2$ and $3d^{10}$. — 1

(ii)

highest: +5 (or V) ✓

lowest: –3 (or –III) ✓ — 2

(iii)

two elements: fluorine (F) ✓ and oxygen (O) ✓ — 2

(iv)

formulae: AsF_5 ✓ and As_2O_5 ✓

Give a mark for $AsCl_5$ if Cl is listed in (iii) — 2

(v)

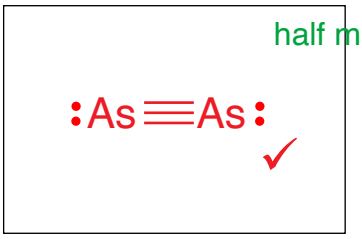
Group: Group 1 ✓ — 2

(vi)

formula: Na_3As ✓

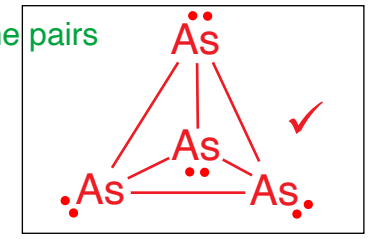
Allow any Group 1 metal, M_3As or hydrogen, AsH_3

1(b) (i)



✓

half mark if no lone pairs



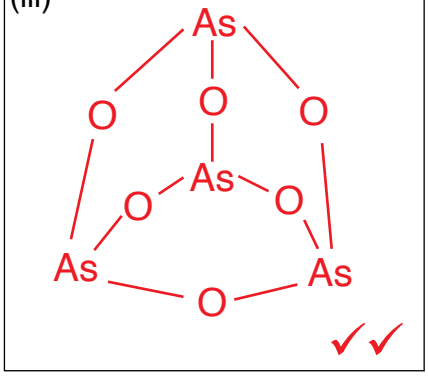
✓ — 2

(ii)

equation: $4As(s) + 3O_2(g) \longrightarrow As_4O_6(s)$ — 1

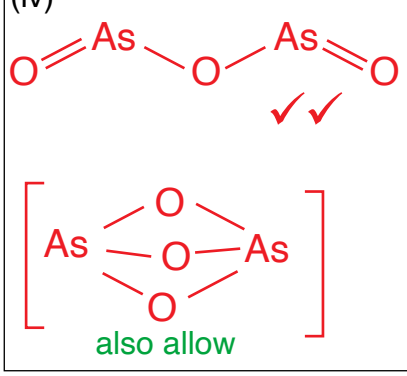
Allow any balanced equation that gives either As_2O_3 or As_4O_6

(iii)



✓✓

(iv)



✓✓

also allow — 4

Page total 16

Marks available

1(c) (i) -1 ✓ — 1

(ii) $FeAsS(s) \longrightarrow FeS(s) + As(s)$ ✓ — 1

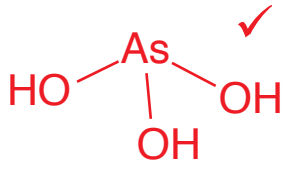
(iii) $4FeAsS(s) + 3O_2(g) \longrightarrow 4FeS(s) + As_4O_6(s)$ ✓

Allow $2FeAsS(s) + 3/2O_2(g) \longrightarrow FeS(s) + As_2O_3(s)$ or 2× this — 1

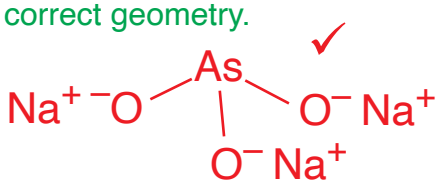
(iv) $4FeAsS(s) + 10O_2(g) \longrightarrow 2Fe_2O_3(s) + 4SO_2(g) + As_4O_6(s)$ ✓

Allow half these quantities to form $As_2O_3(s)$ — 1

1(d) (i) Do not worry about the correct geometry. ✓

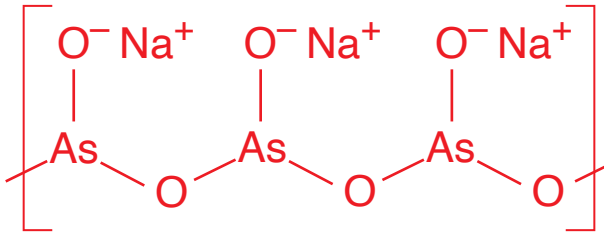


Do not allow $HAs{=}O(OH)_2$



allow 'Na–O' or 'NaO' in structure — 2

(ii)



1 mark correct charges O^- and Na^+

1 mark correct structure ✓✓ — 2

(iii) $3As_4O_6(s) + 14H_2O(l) + 8HNO_3(aq) \longrightarrow 12H_3AsO_4(aq) + 8NO(g)$ ✓

Allow $3As_2O_3(s) + 7H_2O(l) + 4HNO_3(aq) \longrightarrow 6H_3AsO_4(aq) + 4NO(g)$ — 1

1(e) (i)

	H_2O	As_2O_3	CuO
	0.024 g	0.264 g	0.212 g
molar ratio	0.024 / 18.016	0.264 / 197.84	0.212 / 79.55
=	0.00133	0.00133	0.00266
=	1	1	2

$[H_2O + As_2O_3 + 2CuO] = [As_2Cu_2H_2O_6] = [AsCuHO_3]$ ✓✓

one mark if empirical formula doubled — 2

(ii) $2CuHAsO_3(s) + 6NaOH(aq) \longrightarrow Cu_2O(s) + Na_3AsO_3(aq) + Na_3AsO_4(aq) + 4H_2O(l)$

Allow $2CuHAsO_3(s) + 4NaOH(l) \longrightarrow Cu_2O(s) + NaAsO_2(aq) + Na_3AsO_4(aq) + 3H_2O(l)$ ✓✓ — 2

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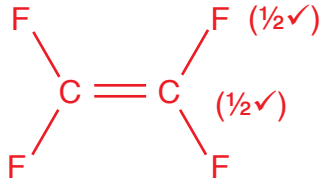
Marks available

2(a) (i)

$2CHClF_2 \longrightarrow C_2F_4 + 2HCl$ ✓

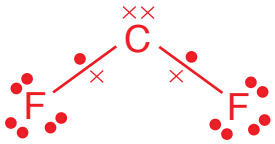
1

(ii) Predict bond angles ca. 120°



(Actual bond angles: CCF 123.8°; FCF 112.4°)

(iii)



✓

2

2(b) (i)

$C_2F_4(g) \longrightarrow C(s) + CF_4(g)$ ✓

1

(ii) Need to circle ALL THREE for two marks.

is oxidised is reduced disproportionates. ✓✓

One mark if only circles disproportionates, or just first two. No other marks.

2

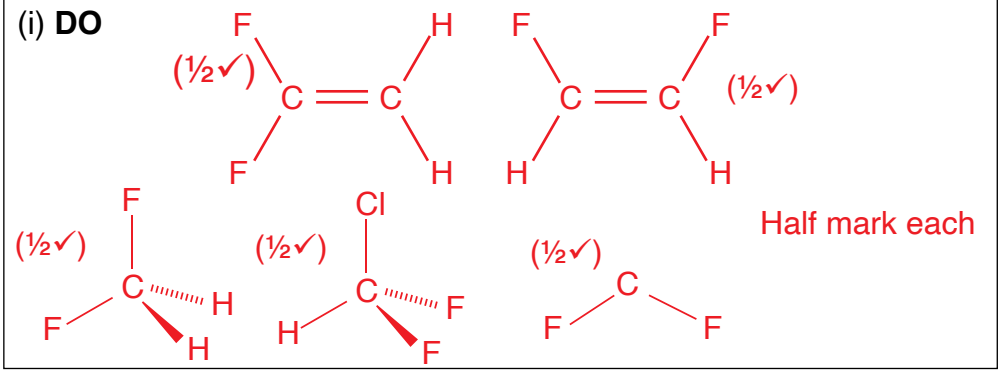
(iii)

A B C D E ✓

1

2(c)

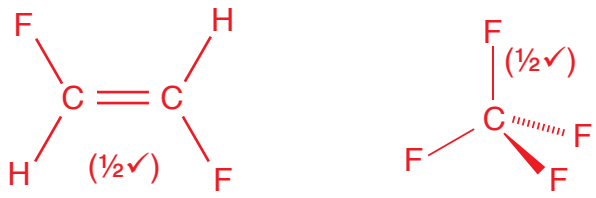
(i) DO



Half mark each

4

(ii) DO NOT Half mark each



Extra half mark if all 7 correct

2(d) (i)

(½✓) F (½✓) Cl (½✓) Se (½✓) Fe (½✓) Na (½✓) K

Give one mark for if all in reverse order →

3

(ii) smallest

Helium, He ✓✓

(iii) greatest

Caesium, Cs ✓

Give full mark for Francium, Fr

3

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if ALL in the wrong order of 2(d)i, allow e.c.f. in (ii) & (iii), i.e. answers other way round.

Marks available

2(e) (i) 0^{o} ✓ — 1

(ii) **A1-A2-A7-B7-B8-B13-C13 - C14-C19-D19 - D20-D25-E25** No partial credit. 3 marks or 0. ✓✓✓ — 3

(iii) **A** only **B** only **C** only **A** & **B** only **A** & **C** only **B** & **C** only **all three**

✓ — 1

(iv) 13 atoms in the helix, the 14th is under the first, so: $C_{14}F_{30}$ ✓ — 1

2(f) (i) $d_{rel} = 2.612 - [0.058 \times \log_{10}(10^7)] = 2.206$ ✓ — 1

(ii) RMM of one $-CF_2-$ unit $= 12 + (2 \times 19) = 50$

Therefore number of carbons in mass of 10^7

$= 10^7 / 50 =$ 200,000 $(=2 \times 10^5)$ ✓ — 1

(iii) $2.18 = 2.612 - 0.058 \times \log_{10}(M_{av})$

$0.058 \times \log_{10}(M_{av}) = (2.612 - 2.18)$

$\log_{10}(M_{av}) = (2.612 - 2.18) / 0.058$

$M_{av} = 10 \exp [(2.612 - 2.18) / 0.058] = 2.8 \times 10^7$ ✓ — 1

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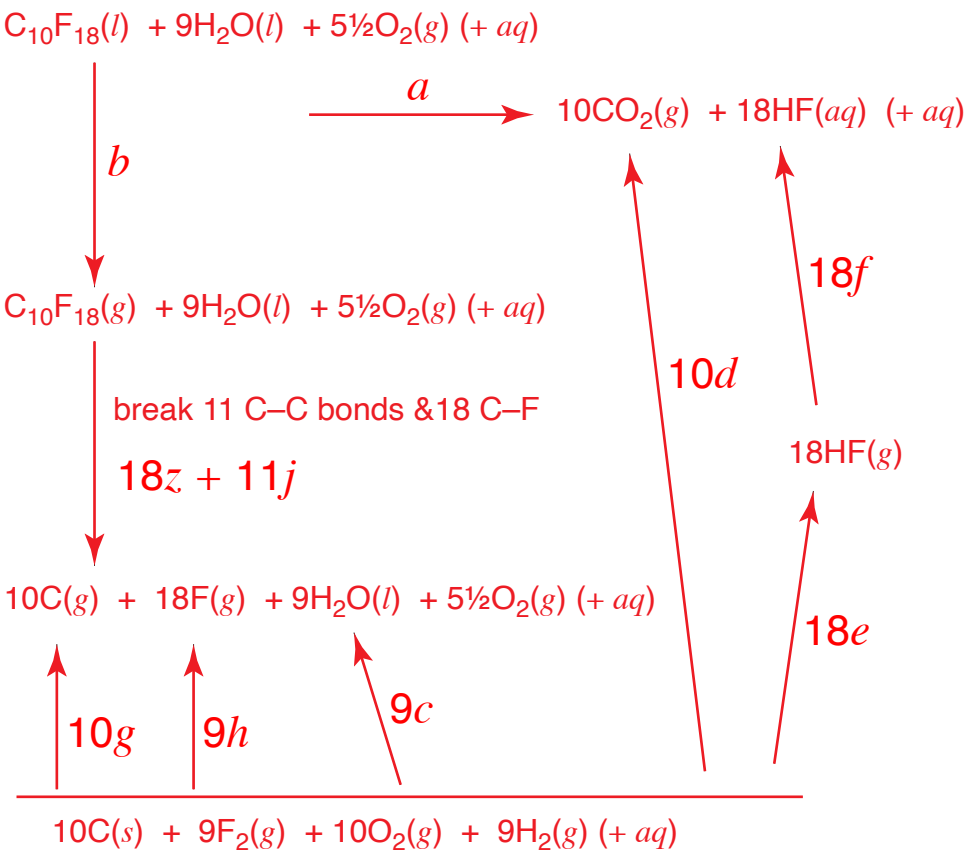
2(g) (i)



$18z + 11j$

$= -b + a - 10d - 18f - 18e + 9c + 9h + 10g$

$18z$

$= -b + a - 10d - 18f - 18e + 9c + 9h + 10g - 11j$

Give half a mark for each correct number with the wrong sign – but 7 marks if ALL correct with wrong sign.

If all divided by the wrong factor '18' (due to wrong number of C–F bonds), and signs correct give 7

If all divided by the wrong factor '18' (due to wrong number of C–F bonds), and all signs incorrect give 5

$z =$ [+1/18] a [−1/18] b [+9/18 +1/2] c [−10/18 −5/9] d [−1] e

[−1] f [+10/18 +5/9] g [+9/18 +1/2] h [−11/18] j kJ mol^{-1}

9

(ii) putting in the values gives value for C–F bond strength:

No error carried forward. = +494kJ mol^{-1} ✓

1

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Marks available

2(h) (i)

5.03×10^{-3} moles of O_2 in 1 mol $C_{10}H_{18}$

RMM of $C_{10}H_{18}$ = (12.01 × 10) + (19.0 × 18) = 462.1

1.917 g of $C_{10}H_{18}$ has a volume of 1 mL

So 1 mol of $C_{10}H_{18}$ has a volume of 462.1 / 1.917 mL

= 241.05 mL ✓

241.05 mL of $C_{10}H_{18}$ dissolves $(5.03 \times 10^{-3} \times 24000)$ mL O_2

so 1 mL of $C_{10}H_{18}$ dissolves $(5.03 \times 10^{-3} \times 24000) / 241.05$ mL O_2

= 0.501 mL ✓✓

Solubility = 0.501 mL O_2 / mL of $C_{10}H_{18}$

3

2(h) (ii)

Haemoglobin in 5L of blood dissolves 50 × 20.1 mL of O_2

= 1005 mL

5L of plasma holds in 22.8 × 5 mL of O_2

= 114 mL

so 5L of blood holds in (1005 + 114) = 1119 mL of O_2 ✓

From above, 0.501 mL O_2 is dissolved in 1 mL of $C_{10}H_{18}$

so 1119 mL O_2 is dissolved in 1119 / 0.501 mL of $C_{10}H_{18}$

= 2234 mL of $C_{10}H_{18}$ ✓

= 2.23 L of $C_{10}H_{18}$

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

2

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