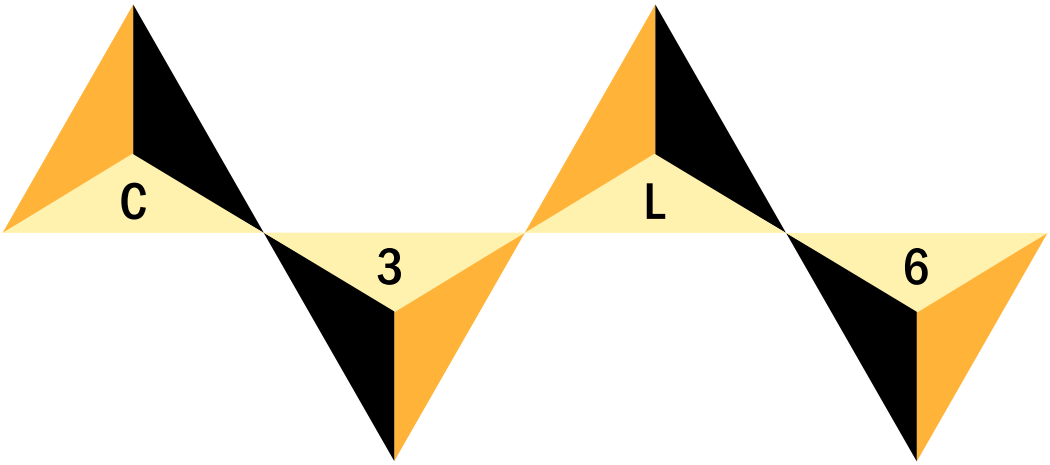


Cambridge Chemistry Challenge Lower 6th

International Year of the Periodic Table

June 2019

Marking scheme for teachers

(please also read the additional instructions)

	p2	p3	p4	p5	p6	p7	p8	p9	p10	Total
mark	8	8	7	5	7	10	6	10	3	**64**

Marks available

1(a)

(i) Oxidation state of indium: **[1]**

(III) or +3 ✓

(ii) Equation for indium metal and dilute nitric acid: **[1]**

$In(s) + 3HNO_3\ (aq) \longrightarrow In(NO_3)_3\ (aq) + 3/2H_2\ (g)$ ✓

[Do not penalise lack of state symbols or if doubled.]

(iii) Oxidised species: indium ½✓ **[1]**

Reduced species: H^+ (accept hydrogen) ½✓

(iv) Equation for indium metal and conc. nitric acid: **[1]**

$In(s) + 4HNO_3\ (aq) \longrightarrow In(NO_3)_3\ (aq) + NO + 2H_2O(l)$ ✓

(v) Equation for formation of indium hydroxide: **[1]**

$In(NO_3)_3\ (aq) + 3NaOH\ (aq) \longrightarrow In(OH)_3\ (s) + 3NaNO_3\ (aq)$ ✓

(vi) Equation for formation of indium oxide: **[1]**

$2In(OH)_3\ (s) \longrightarrow In_2O_3\ (s) + 3H_2O\ (l)$ ✓

(vii) Maximum mass of indium oxide: **[2]**

1 g of indium ≡ 1/114.82 mol

1 mol of indium gives ½ mol of In_2O_3

RMM of In_2O_3 = 2(114.82) + 3(16) = 277.64

max. mass of In_2O_3 = $\frac{2(114.82) + 3(16)}{2(114.82)}$ = 1.21 g ✓✓

Page total 8

Marks available

1(b)

(i) Apparent RMM of indium if oxide is InO: **[1]**

0.5135 g of indium combines with (0.6243 - 0.5135) g oxygen = 0.1108 g

16 g of oxygen would therefore combine with

$$\frac{0.5135}{(0.6243 - 0.5135)} \times 16 = 74.2 \text{ g of indium}$$

apparent RAM = 74.2 ✓

[c.f. mass in Mendeleev's table 75.6]

(ii) Apparent RMM of indium if oxide is InO_2: **[1]**

0.5135 g of indium combines with (0.6243 - 0.5135) g oxygen = 0.1108 g

32 g of oxygen would therefore combine with

$$\frac{0.5135}{(0.6243 - 0.5135)} \times 32 = 148.3 \text{ g of indium}$$

apparent RAM = 148.3 ✓

1(c)

(ii) no. of protons = 53 ✓ no. of neutrons = 74 ✓ **[3]**

no. of electrons = 54 ✓

1(d) **[3]**

total fraction of lighter isotopes = x

fraction of Te-130 = y

$x + y = 1$

$126.412449\,x + 129.906223\,y = 127.60$

$126.412449\,(1 - y) + 129.906223\,y = 127.60$ ✓

$(129.906223 - 126.412449)\,y = 127.60 - 126.412449$

$$y = \frac{127.60 - 126.412449}{129.906223 - 126.412449} = 0.3399 \quad \text{i.e. } 33.99\%$$ ✓

% of tellurium-130 = 33.99 ✓

(Allow 34%)

Page total 8

Marks available

1(e)

(i) Equation for thallium(III) nitrate and potassium iodide: **[1]**

$T\ell(NO_3)_3\ (aq) + 3KI\ (aq) \longrightarrow T\ell I\ (s) + I_2(aq) + 3KNO_3\ (aq)$ ✓

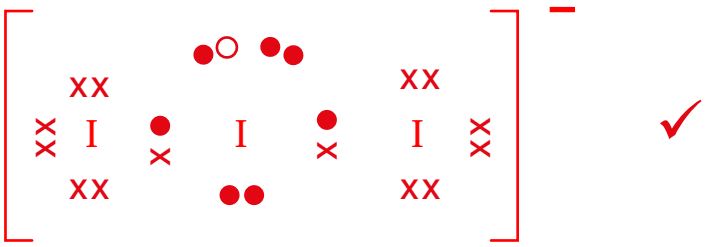
[Do not penalise lack of state symbols or if written as ionic]

1(f)

(i) Oxidation state of Cs: +1 ✓ **[1]**

(ii) Average oxidation state of I: –1/3 ✓ **[1]**

(iii) Dot & cross diagram: **[1]**



✓

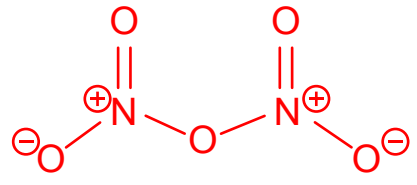
(iv) Bond angle: 180° ✓ **[1]**

1(g)

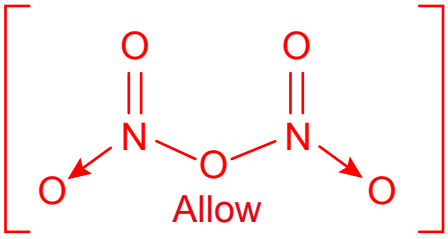
(i) Formula for nitrogen(V) oxide: N_2O_5 ½✓

Formula for niobium(V) oxide: Nb_2O_5 ½✓ **[1]**

(ii) Structure of molecular nitrogen(V) oxide: **[1]**



✓



Allow

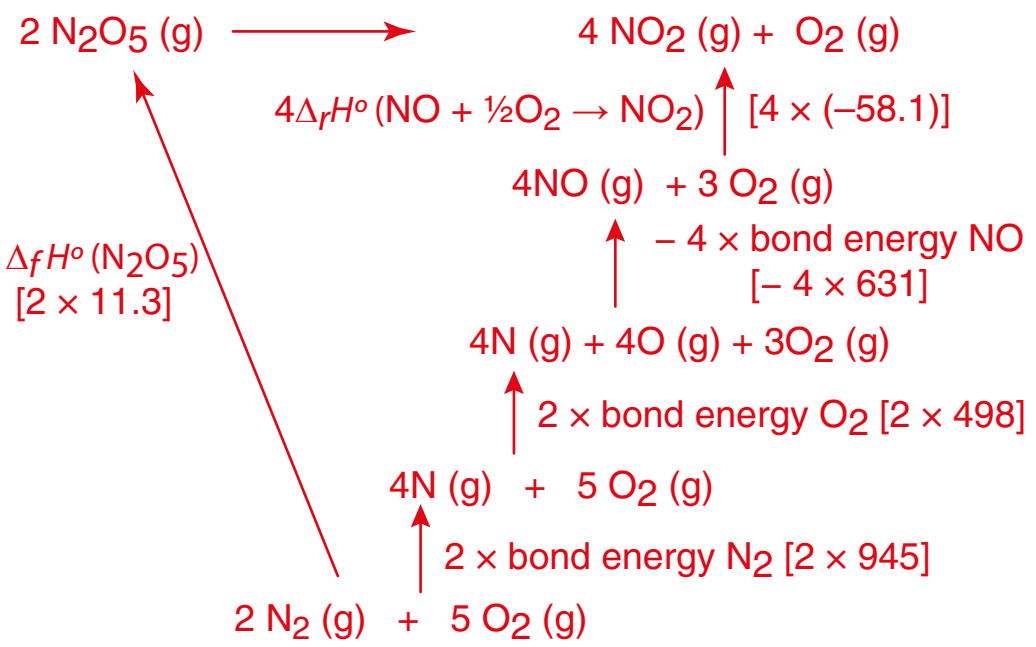
Page total 7

Marks available

1(g)

(iii) Cation: $NO_2^{\oplus}$ ½✓ Anion: $NO_3^{\ominus}$ ½✓ **[1]**

(iv) Standard enthalpy change: **[3]**



$\Delta_r H^o = -(2 \times 11.3) + (2 \times 945) + (2 \times 498) - (4 \times 631) - (4 \times 58.1)$

$= +107 \text{ kJ mol}^{-1}$ ✓✓✓

(v) Two formulae of lithium niobate(V): **[1]**

$LiNbO_3$ ½✓ Li_3NbO_4 ½✓

Page total 5

Marks available

1(h)

(i) Electron configuration of calcium:

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$ ✓ **[1]**

Electron configuration of zinc:

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

[accept order of 4s and 3d reversed]

(ii) Valence electrons of barium: $6s^2$ ½✓

Valence electrons of mercury: $6s^2$ ½✓ **[1]**

(iii) Valence electrons of manganese: $4s^2\ 3d^5$ ½✓

Valence electrons of bromine: $4s^2\ 4p^5$ ½✓ **[1]**

(iv) Electron configuration of oganesson:

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}$
$5p^6\ 6s^2\ 4f^{14}\ 5d^{10}\ 6p^6\ 7s^2\ 5f^{14}\ 6d^{10}\ 7p^6$ **[1]**

1(j)

(i) Number of 5g orbitals: 9 **[1]**

(ii) Atomic number of element beneath Og:

Og = 118

need to add 2 + 18 + 14 + 10 + 6 = 50

118 + 50 = 168 ✓ **[1]**

Page total 7

Marks available

2(a)

(i) Oxidation state of iodine in periodic acid: **[1]**

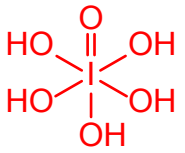
(VII) or +7 ✓

(ii) Balanced equation for the formation of metaperiodic acid: **[1]**

H_5IO_6 (s) ⟶ HIO_4 (s) + $2H_2O$ (g) ✓

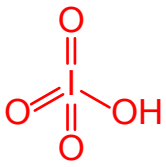
[Do not penalise lack of state symbols]

(iii) Structure of orthoperiodic acid: **[1]**



✓

(iv) Structure of metaperiodic acid: **[1]**



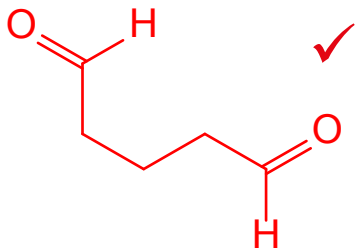
✓

2(b) Circle the term describing the role of periodic acid: **[1]**

Oxidising agent ✓ Reducing agent Dehydrating agent Catalyst

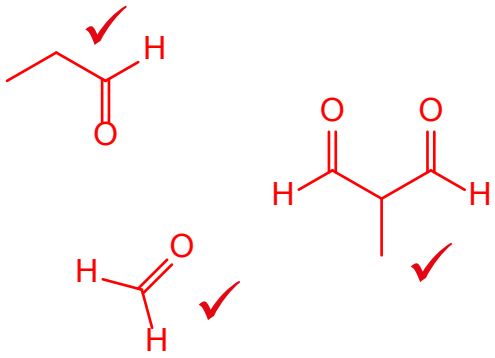
2(c) Structures formed on reaction with periodic acid: **[4]**

(i)



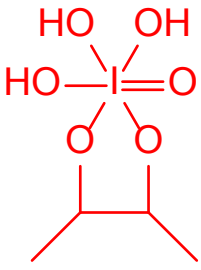
✓

(ii)



✓ ✓ ✓

2(d) Structure of the cyclic intermediate: **[1]**



✓

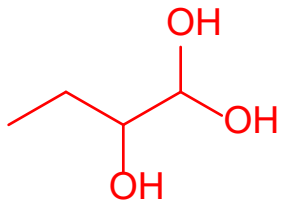
[It does not matter to which position around the Iodine the alcohol groups are attached.]

Page total 10

2(e)

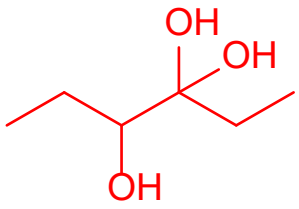
(i) Hydrated forms:

Aldehyde A



½✓

Ketone B

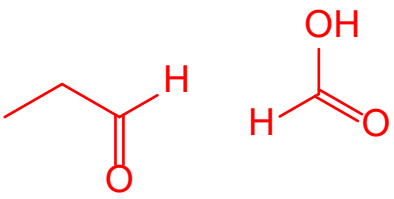


½✓

[1]

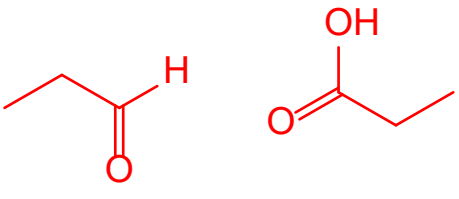
(ii) Products resulting from reaction with periodic acid:

Aldehyde A



½✓ ½✓

Ketone B

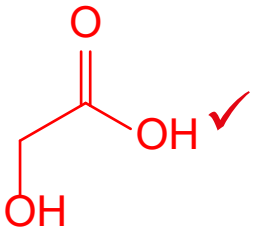


½✓ ½✓

[2]

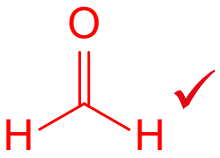
2(f) Structures for compounds C, D and E:

Compound C

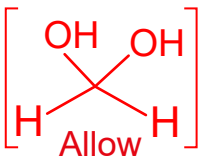


✓

Compound D



✓



[3]

Compound E



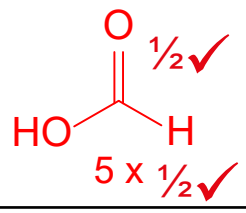
✓

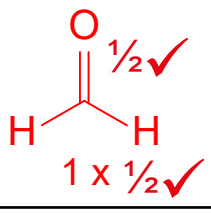
Page total 6

Marks available

2(g)

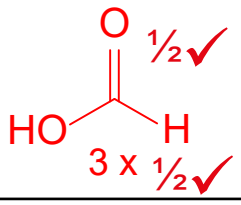
(i) Products of complete reaction of glucose with periodic acid: **[2]**

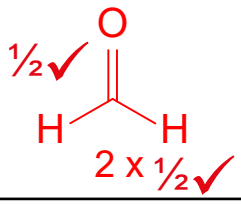


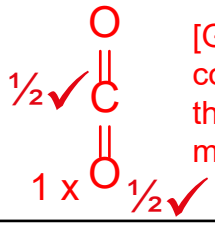


[Give half mark for each correct structure, and for the stoichiometry. Accept methanal or hydrate.]

(ii) Products of complete reaction of fructose with periodic acid: **[3]**







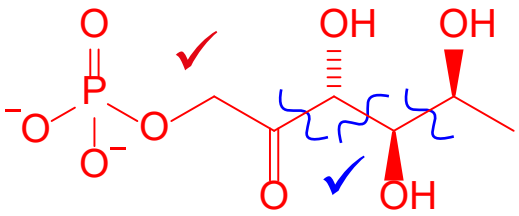
[Give half mark for each correct structure, and for the stoichiometry. Accept methanal or hydrate.]

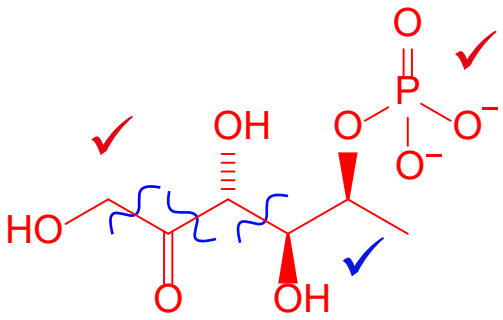
2(h)

(i) Structure(s) of fuculose phosphate consistent with experiment **[3]**

& (ii) with C - C bonds that are broken on reaction with periodic acid indicated on the structure(s): **[2]**

Addition of phosphate at carbon-3 or carbon-4 gives a product that reacts with two equivalents of periodic acid. Addition of phosphate at carbon-1 or carbon-5 gives products consistent with the experimental data:





(i) If both structures are given correctly award two marks (do not penalise incorrect formula/structure for the phosphate group).

If all four structures are shown, give 0 marks.

For two correct structures plus one incorrect structure award 1 mark.

An addition mark should be awarded for giving a correct formula for the phosphate group, irrespective of whether the phosphate is at the correct position. Accept both the protonated and deprotonated forms.

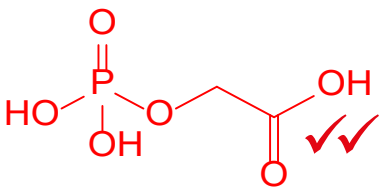
(ii) Award one mark for each of the correct products where the correct C-C bonds are indicated on the diagram.

Page total 10

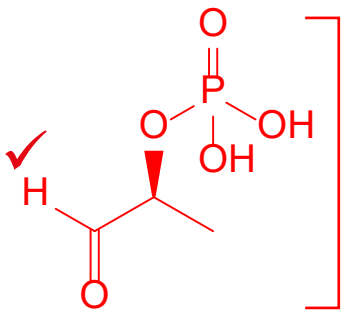
Marks available

2(j)

(i) Structure for the phosphorus-containing product: **[2]**



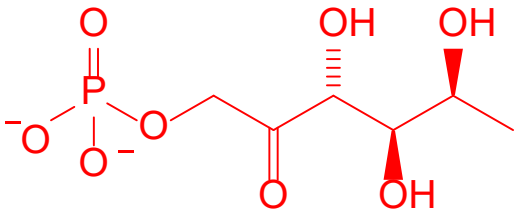
OR



The phosphorylated fragment from reaction of fuculose-1-phosphate with periodic acid (above left) has a molecular mass of 156.03 in the fully protonated form, and hence contains 15.4% carbon. Award 2 marks if only this structure is given, 1 mark if this structure and another structure is given.

The phosphorylated fragment from fuculose-5-phosphate (above right) has 23.4% carbon in its fully protonated form. Award 1 mark if only this structure is given, 0 marks if this structure and another incorrect one is given.

(ii) Structure(s) from part h giving the correct phosphorus-containing product on reaction with periodic acid: **[1]**



Accept the fully protonated, singly protonated and fully deprotonated form of the phosphate group.

Page total 3