

# 38th INTERNATIONAL CHEMISTRY OLYMPIAD

## UK Round One - 2006

### MARKING SCHEME

#### Notes

Chemical equations may be given as sensible multiples of those given here.

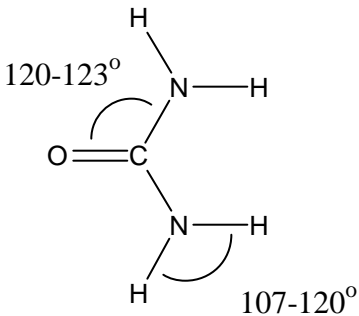
State symbols do not need to be included in the chemical equations to obtain the mark(s).

Answers should be given to an appropriate number of significant figures although the marker should only penalise this once.

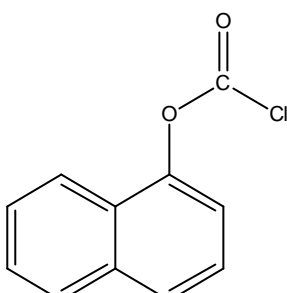
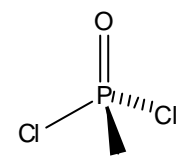
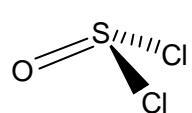
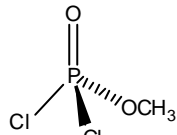
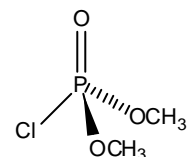
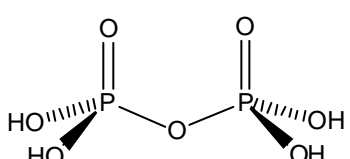
Total 78 marks.

Question 1		Answer	Marks
(a)		$C_{12}H_{22}O_{11} + 12O_2 \longrightarrow 12CO_2 + 11H_2O$	1
(b)		Allow 110 kJ or 111kJ (rounded to 3 sig fig)	1
(c)		95 sweets [Allow ecf from (b)]	1
(d)		Mass of sodium hydrogencarbonate = 0.0210g Mass of tartaric acid = 0.0188g	1 1
(e)		<p>2 marks for all 3 structures shown correctly. 1 further mark for enantiomers correctly identified.</p> <p>enantiomers</p>	3
(f)		None	1

9 marks

Question 2			
		Answer	Marks
(a)		$C_8H_{18} + 12\frac{1}{2}O_2 \longrightarrow 8CO_2 + 9H_2O$	1
(b)	i)	$\underline{C}O + \frac{1}{2}\underline{O}_2 \longrightarrow CO_2$	1 for both equations correct
	ii)	$\underline{C}O + \underline{H}_2O \longrightarrow CO_2 + H_2$	
(c)	i)	$\underline{N}O + \underline{C}O \longrightarrow \frac{1}{2}N_2 + CO_2$	1 for both equations correct
	ii)	$\underline{N}O + \underline{H}_2 \longrightarrow \frac{1}{2}N_2 + H_2O$	
(d)		$\underline{C}e_2O_3 + \frac{1}{2}\underline{O}_2 \rightleftharpoons 2CeO_2$	1
(e)		$\underline{C} + 2\underline{N}O_2 \longrightarrow CO_2 + 2NO$	1
(f)		<p>1 mark for structure shown correctly. 1 mark for both bond angles correct.</p> 	2
(g)		$CO(NH_2)_2 + H_2O \longrightarrow CO_2 + 2NH_3$	1
(h)	i)	$2\underline{N}H_3 + 3\underline{N}O \longrightarrow 2\frac{1}{2}N_2 + 3H_2O$	1
	ii)	$4\underline{N}H_3 + 3\underline{N}O_2 \longrightarrow 3\frac{1}{2}N_2 + 6H_2O$	1
(i)		<p>Award marks here provided that candidates have a minimum of 5 of the 8 equations correct. Allow 4 marks for all 8 redox changes correct, 3 marks for 7, 2 marks for 6 and 1 mark for 5 redox changes correct.</p> <p>See underlining (b), (c), (d), (e) and (h) above</p>	4

14 marks

Question 3		Answer	Marks
(a)		$\text{CH}_3\text{COCl} + \text{H}_2\text{O} \longrightarrow \text{CH}_3\text{COOH} + \text{HCl}$	1
(b)		$\text{CH}_3\text{CH}_2\text{COCl} + \text{CH}_3\text{CH}_2\text{OH} \longrightarrow \text{CH}_3\text{CH}_2\text{COOCH}_2\text{CH}_3 + \text{HCl}$	1
(c)			1
(d)		<p>1 mark for each structure with correct shape indicated. 1 mark for both oxidation states correct.</p> <div style="display: flex; justify-content: space-around; align-items: flex-start;"> <div style="text-align: center;">  <p>Tetrahedral P = +5</p> </div> <div style="text-align: center;">  <p>Pyramidal S = +4</p> </div> </div>	3
(e)		$\text{SOCl}_2 + \text{H}_2\text{O} \longrightarrow \text{SO}_2 + 2\text{HCl}$ $\text{SOCl}_2 + 2\text{H}_2\text{O} \longrightarrow \text{H}_2\text{SO}_3 + 2\text{HCl}$ [allow either answer]	1
(f)	i)		1
	ii)		1
(g)		 $5\text{H}_3\text{PO}_4 + \text{POCl}_3 \longrightarrow 3\text{H}_4\text{P}_2\text{O}_7 + 3\text{HCl}$	2

11 marks

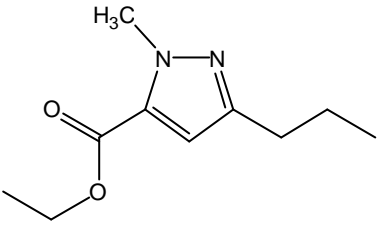
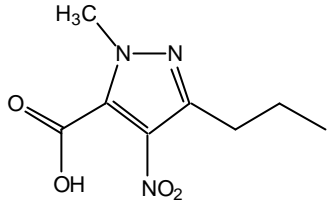
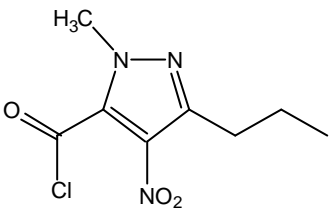
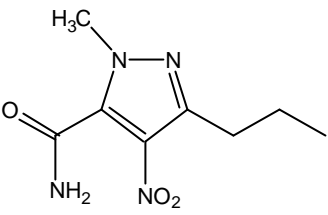
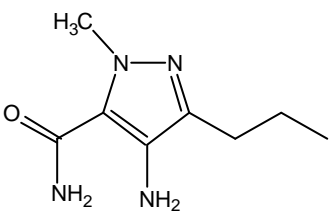
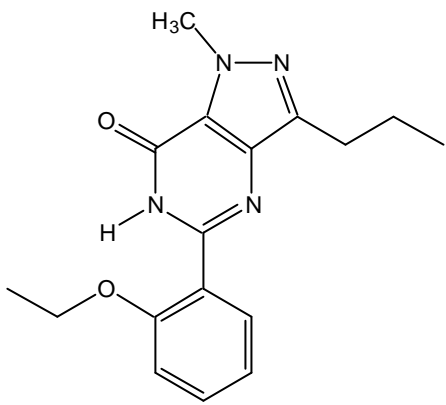
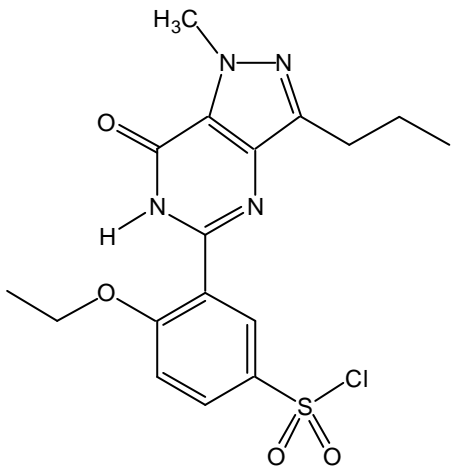
Question 4			
		Answer	Marks
(a)		A: $\text{CuSO}_4 \cdot 3\text{H}_2\text{O}$	1
		B: $\text{CuSO}_4 \cdot \text{H}_2\text{O}$	1
		C: $\text{CuSO}_4$	1
(b)		E: $\text{CuO}$	1
		F: $\text{Cu}_2\text{O}$	1
		$2\text{CuO} \longrightarrow \text{Cu}_2\text{O} + \frac{1}{2}\text{O}_2$	1
(c)		D: $\text{Cu}_2\text{SO}_5$	1

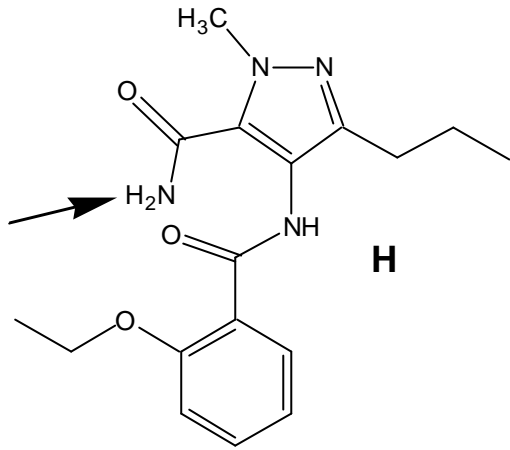
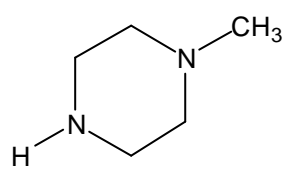
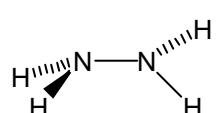
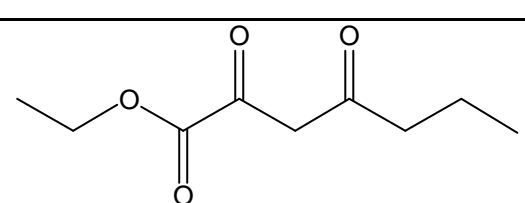
7 marks

Question 5			
		Answer	Marks
(a)		$\text{NaClO}_3 \longrightarrow \text{NaCl} + \frac{1}{2}\text{O}_2$	1
(b)	i)	$\text{BaO}_2 + \text{Cl}_2 \longrightarrow \text{BaCl}_2 + \text{O}_2$	1
	ii)	$\text{BaO}_2 + 2\text{HClO} \longrightarrow \text{BaCl}_2 + \frac{1}{2}\text{O}_2 + \text{H}_2\text{O}$	1
(c)		$15\text{dm}^3$	1
(d)		Allow 117g or 178g	1
(e)		<i>2 marks for all 3 oxidation states correct. 1 mark for 2 correct</i>	
	i)	-2	2
	ii)	-1	
iii)	$-\frac{1}{2}$		
(f)	i)	$2\text{KO}_2 + \text{H}_2\text{O} \longrightarrow 2\text{KOH} + \frac{1}{2}\text{O}_2$	1
	ii)	$2\text{KOH} + \text{CO}_2 \longrightarrow \text{K}_2\text{CO}_3 + \text{H}_2\text{O}$ [Allow also $\text{KOH} + \text{CO}_2 \longrightarrow \text{KHCO}_3$ ]	1

9 marks

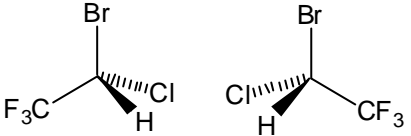
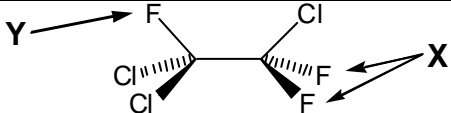
**Question 6**

	Answer	Marks
(a)	<p><i>Allow 1 mark for each correct structure. Give credit where the candidate has identified the relevant part of the structure correctly – do not deduct marks for trivial errors in copying the remainder of the molecule.</i></p> <div style="display: flex; flex-wrap: wrap; justify-content: space-around;"> <div style="text-align: center; margin: 10px;">  <p><b>B</b></p> </div> <div style="text-align: center; margin: 10px;">  <p><b>D</b></p> </div> <div style="text-align: center; margin: 10px;">  <p><b>E</b></p> </div> <div style="text-align: center; margin: 10px;">  <p><b>F</b></p> </div> <div style="text-align: center; margin: 10px;">  <p><b>G</b></p> </div> <div style="text-align: center; margin: 10px;">  <p><b>I</b></p> </div> <div style="text-align: center; margin: 10px;">  <p><b>J</b></p> </div> </div>	7

Question 6 continued		Answer	Marks
(b)	i)	HCl(aq)	1
	ii)	NH <sub>3</sub>	1
(c)			1
(d)			1
(e)	i)	 <p>allow any diagram showing correct structure</p>	1
	ii)		1

13 marks

Question 7			Marks																															
(a)	$C^{35}Cl_2F_2^+ = 120$	$C^{35}Cl^{37}ClF_2^+ = 122$	1																															
	ratio 9 : 6 : 1	$C^{37}Cl_2F_2^+ = 124$	1																															
(b)	<p>1 mark for peaks at correct masses, 1 mark for correct relative intensities and 1 mark for the formulae of the ions indicated correctly (allow mark if '+' sign omitted - as here).</p>	3																																
(c)	ratio 1 : 2 : 3 : 4 : 3 : 2 : 1	1																																
(d)	<table border="1"> <thead> <tr> <th></th> <th>Common name</th> <th>Structural formula</th> <th>Number of different fluorine environments</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>CFC-113</td> <td><math>Cl_2FC-CClF_2</math></td> <td>2</td> </tr> <tr> <td>B</td> <td>CFC-113a</td> <td><math>Cl_3C-CF_3</math></td> <td>1</td> </tr> <tr> <td>C</td> <td>HFC-134a</td> <td><math>F_3C-CH_2F</math></td> <td>2</td> </tr> <tr> <td>D</td> <td>CFC-11 (Freon-11, R-11)</td> <td><math>CCl_3F</math></td> <td>1</td> </tr> <tr> <td>E</td> <td>CFC-12 (Freon-12, R-12)</td> <td><math>CCl_2F_2</math></td> <td>1</td> </tr> <tr> <td>F</td> <td>CFC-13</td> <td><math>CClF_3</math></td> <td>1</td> </tr> <tr> <td>G</td> <td>Halon 1211</td> <td><math>CBrClF_2</math></td> <td>1</td> </tr> </tbody> </table>		Common name	Structural formula	Number of different fluorine environments	A	CFC-113	$Cl_2FC-CClF_2$	2	B	CFC-113a	$Cl_3C-CF_3$	1	C	HFC-134a	$F_3C-CH_2F$	2	D	CFC-11 (Freon-11, R-11)	$CCl_3F$	1	E	CFC-12 (Freon-12, R-12)	$CCl_2F_2$	1	F	CFC-13	$CClF_3$	1	G	Halon 1211	$CBrClF_2$	1	3 marks for all 7 correct, 2 marks for 6 correct, 1 mark for 5 correct
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E	CFC-12 (Freon-12, R-12)	$CCl_2F_2$	1																															
F	CFC-13	$CClF_3$	1																															
G	Halon 1211	$CBrClF_2$	1																															

Question 7 continued		Marks																																
(e)	<p>1 mark for structure showing -CF<sub>3</sub> group. 1 mark for mirror images shown correctly.</p> 	2																																
(f)	<table border="1"> <thead> <tr> <th></th> <th>Common name</th> <th>Structural formula</th> <th>Expected intensity ratio</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>CFC-113</td> <td>Cl<sub>2</sub>FC-CClF<sub>2</sub></td> <td>1 : 2</td> </tr> <tr> <td>B</td> <td>CFC-113a</td> <td>Cl<sub>3</sub>C-CF<sub>3</sub></td> <td></td> </tr> <tr> <td>C</td> <td>HFC-134a</td> <td>F<sub>3</sub>C-CH<sub>2</sub>F</td> <td>3 : 1</td> </tr> <tr> <td>D</td> <td>CFC-11 (Freon-11, R-11)</td> <td>CCl<sub>3</sub>F</td> <td></td> </tr> <tr> <td>E</td> <td>CFC-12 (Freon-12, R-12)</td> <td>CCl<sub>2</sub>F<sub>2</sub></td> <td></td> </tr> <tr> <td>F</td> <td>CFC-13</td> <td>CClF<sub>3</sub></td> <td></td> </tr> <tr> <td>G</td> <td>Halon 1211</td> <td>CBrClF<sub>2</sub></td> <td></td> </tr> </tbody> </table>		Common name	Structural formula	Expected intensity ratio	A	CFC-113	Cl <sub>2</sub> FC-CClF <sub>2</sub>	1 : 2	B	CFC-113a	Cl <sub>3</sub> C-CF <sub>3</sub>		C	HFC-134a	F <sub>3</sub> C-CH <sub>2</sub> F	3 : 1	D	CFC-11 (Freon-11, R-11)	CCl <sub>3</sub> F		E	CFC-12 (Freon-12, R-12)	CCl <sub>2</sub> F <sub>2</sub>		F	CFC-13	CClF <sub>3</sub>		G	Halon 1211	CBrClF <sub>2</sub>		2
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G	Halon 1211	CBrClF <sub>2</sub>																																
(g)	 <p>Allow 1 mark for the correct structure and 1 mark for correct identification of fluorines.</p>	2																																

15 marks