39th INTERNATIONAL CHEMISTRY OLYMPIAD

UK Round One - 2007

MARKSCHEME

Notes

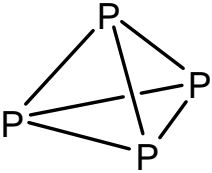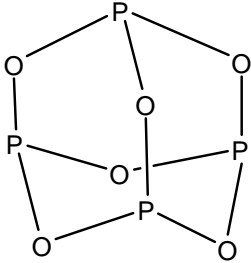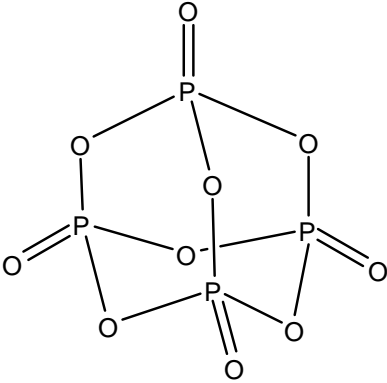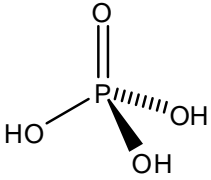Chemical equations may be given as sensible multiples of those given here.

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 penalise this only once.
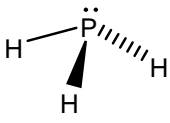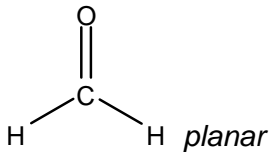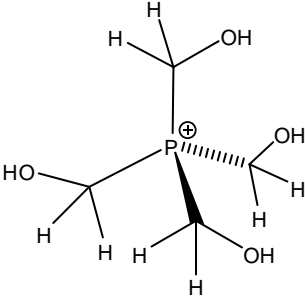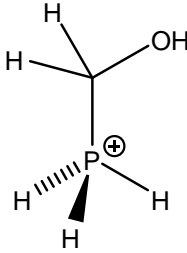
As a general rule, markers should aim to reward correct chemistry. Errors cannot be ignored but markers should ensure that candidates are not penalised for _trivial_ errors.
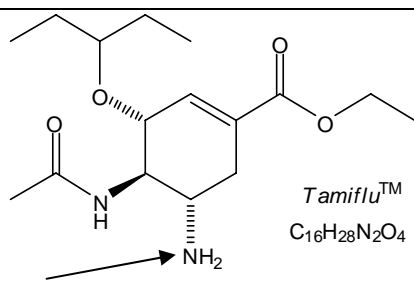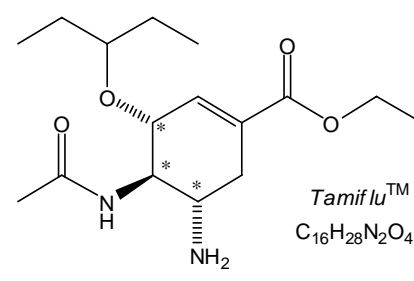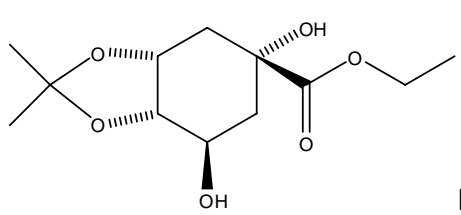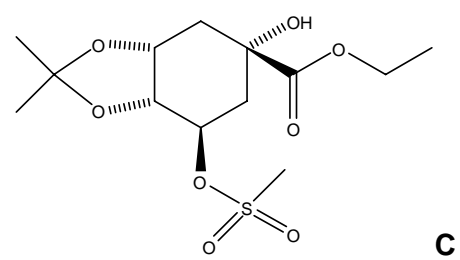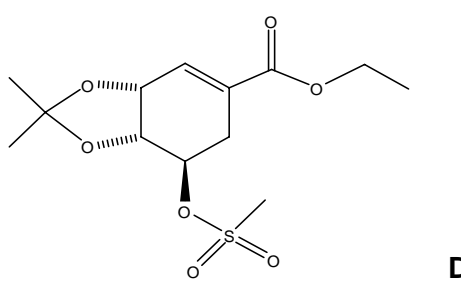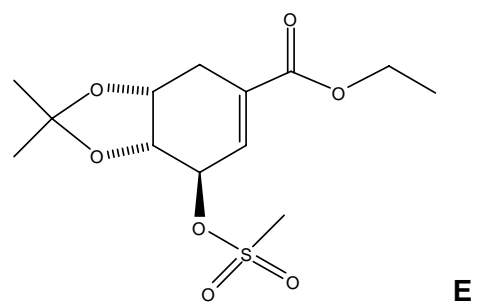
Total mark: 73
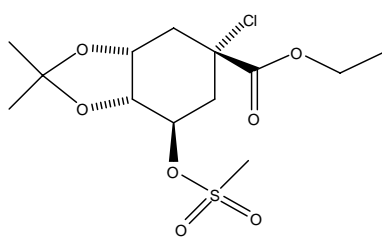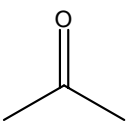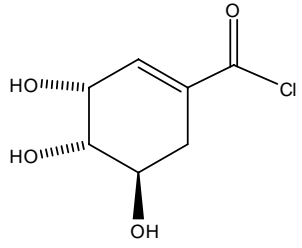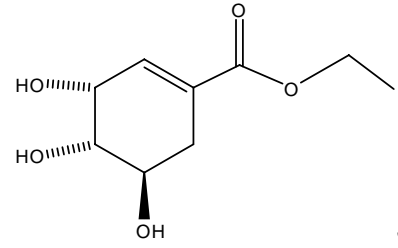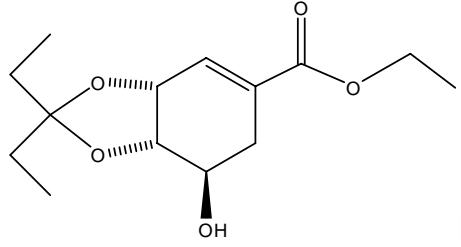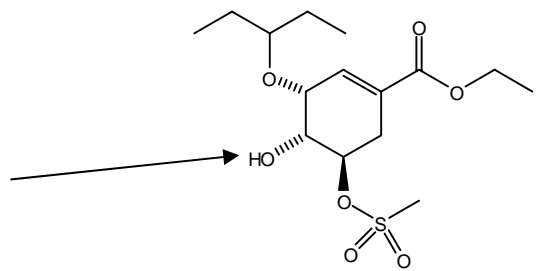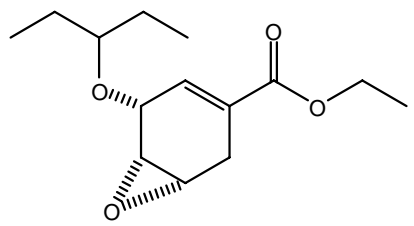
Question 1			Mark
(a)		$H_2 + \frac{1}{2} O_2 \longrightarrow H_2O$	1
(b)		Mass of hydrogen = 80 t	1
		Mass of oxygen = 638 t	1
(c)		Volume of hydrogen = 1470 m^3 Volume of oxygen = 538 m^3 Total tank capacity = 2010 m^3 _2 marks if total tank capacity correct. If incorrect, allow 1 mark for volume of H$_2$ **or** O$_2$ correct._	2
(d)		- 9769 kJ mol^{-1}	1
(e)		2.6 MJ (2.6 x 10^9 kJ) _Don't penalise if – sign present; allow 1 for correct working even if final answer incorrect._	2
			Marks = 8

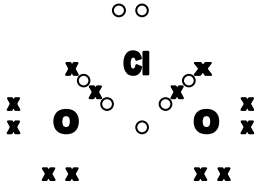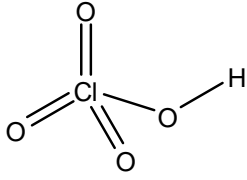| Question 2				Mark
(a)				1
(b)		Number of edges: 6		1
(c)	**i)**	$P_4 + 3O_2 \longrightarrow P_4O_6$	(*allow mark for any correctly balanced equation giving P_2O_3 or P_4O_6*)	1
	ii)	$P_4 + 5O_2 \longrightarrow P_4O_{10}$	(*allow mark for any correctly balanced equation giving P_2O_5 or P_4O_{10}*)	1
(d)		Structure of phosphorus(III) oxide:	**(e)** Structure of phosphorus(V) oxide:	1 + 1
(f)		(*stereochemistry not required*)		1
(g)		$P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$	(*allow balanced equation from P_2O_5*)	1
(h)		Oxidation state of molybdenum: + 6 (*sign not essential for mark*)		1
(i)	**(i)**	Number of vertices: 12	**(ii)** Number of edges: 24	1 + 1
(j)	**(i)**	Number of Mo atoms: 12	**(ii)** Number of O atoms: 40 (*allow 1 mark for 36 O atoms*)	1 + 2
(k)		Overall charge of the molybdophosphate ion: – 3		1
		Formula of ammonium molybdophosphate: $(NH_4)_3Mo_{12}O_{40}P$ (*allow variants e.g. $N_3H_{12}Mo_{12}O_{40}P$*)		1
				Marks = 16

Question 3			Mark
(a)		**C & E**	1
(b)		Concentration of phosphate: 7.5×10^{-4} mol dm^{-3} *(2 marks for fully correct answer, allow 1 mark for correct working if final answer incorrect)*	2
(c)		Form of phosphate: HPO_4^{2-}	1
(d)		$6HCl + La_2(CO_3)_3 \longrightarrow 2LaCl_3 + 3CO_2 + 3H_2O$ *(2 marks if completely correct; 1 mark if incorrect equation but formula for $La_2(CO_3)_3$ is correct)*	2
(e)		8.41×10^{-14} mol dm^{-3}	1
(f)		$LaPO_4$	1
			Marks = 8

Question 4			Mark
(a)		*pyramidal <u>not planar</u>* *planar*	1 + 1
(b)		Number of environments of hydrogen: 2 Ratio: 1:2	1 + 1
(c)		Functional group: -OH *(or alcohol, hydroxyl)*	1
(d)		Number of hydrogen nuclei: 8	1
(e)	(i)	Formula for fragment: CH_2O	1
	(ii)	Formula for the X$^+$ ion: $C_4H_{12}O_4P$ $\oplus$ *(allow correct variants)*	1
	(iii)	*m/z* value: 159	1
(f)	(i)	Structure for X$^+$: (ii) Structure for ion at *m/z* = 65:	1 + 1
			Marks = 11

Question 5			Mark
(a)		*Atom/group indicated should be circled*	1
(b)	**(i)**		1
	(ii)	Total number of stereoisomers: $2^3 = 8$	1
		For parts (c), (d) and (f): for each of the structures, award 1 mark if completely correct as shown below. Deduct ½ mark (for each structure) if stereochemistry incorrect.	
(c)		**B** **C**	1
			1
		D **E**	1
			1

Question 5 continued			Mark
(c)		**F** **H**	1 1
(d)		**I** **J**	1
			1
		K	1
(e)			1
(f)	**M**		1

Question 5 continued			Mark
(f)	N (or O)		1
	O (or N)		1
	P		1
	Q		1
	R		1
			Mark = 19

Question 6				Mark
(a)		Bond angle: 110 – 120° *(actual angle: 117.4)*		1 1
(b)	**(i)**	Oxidation state of chlorine in ClO_2: + 4 Oxidation state of chlorine in $HClO_3$: + 5 Oxidation state of chlorine in $HClO_4$: + 7 *Award 2 marks for all 3 correct, 1 mark for 2 correct*		2
	(ii)	$3HClO_3 \longrightarrow 2ClO_2 + HClO_4 + H_2O$		1
	(iii)	Structure:	Bond angle: 109.5^o (109° 28') *(allow 109°)*	1 1
(c)		$2NaClO_3 + SO_2 \xrightarrow{(H_2SO_4)} 2ClO_2 + Na_2SO_4$ *Allow as ionic*		1
(d)		$2NaClO_3 + (COOH)_2 + H_2SO_4 \longrightarrow 2ClO_2 + 2CO_2 + 2H_2O + Na_2SO_4$ *Allow as ionic: $2ClO_3^- + (COOH)_2 + 2H^+ \longrightarrow 2ClO_2 + 2CO_2 + 2H_2O$*		1
(e)	**(i)**	$NaClO_2$		1
	(ii)	$2NaClO_2 + Cl_2 \longrightarrow 2ClO_2 + 2NaCl$		1
				Marks = 11