

43rd INTERNATIONAL CHEMISTRY OLYMPIAD

UK Round One - 2011

MARKING SCHEME

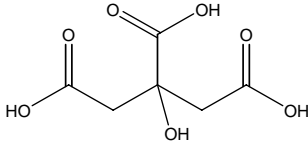
Notes:

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

Formulae can be given by any conventional method (i.e. structural or molecular) unless a particular format is specified by the question.

State symbols do not need to be included in 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 (on the whole paper).

Total marks for paper = 55			
Question 1			
		Answer	Marks
a)		Heat energy transferred to the water for 2.0 g snack = $500 \times 4.18 \times 20.9 \text{ J} = \mathbf{43681 \text{ J}}$ (or $\mathbf{43.7 \text{ kJ}}$) Whole bag of snack = $(43681^* \times 22/2.0)/1000$ = 480 kJ = 115 dietary calories.	1
		<i>Allow 2 or 3 sf. Correct answer scores 2 marks without reference to working. *Allow ecf from first marking point.</i>	1
b)	(i)	AgNO ₃	1
	(ii)	K ₂ CrO ₄	1
c)		Ag ⁺ + Cl ⁻ → AgCl [<i>Allow equation with spectator ions</i>]	1
		Moles silver (nitrate) = $(8.20/1000) \times 0.100 = 8.20 \times 10^{-4}$ <i>Allow ecf from equation.</i> Moles (sodium) chloride from small bag of snack = $8.20 \times 10^{-4} \times 10$ Mass sodium chloride in small bag snack = $(8.20 \times 10^{-4} \times 10) \times 58.44$ = 0.479 g (3sf) <i>Correct answer scores 2 marks without reference to working.</i> <i>Allow 1 mark if correct answer but given to 2 or 4 sf.</i>	2
d)		 <i>Allow any clear representation of the correct structure for 1 mark if not skeletal.</i>	2
e)		None	1

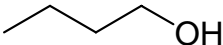
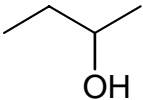
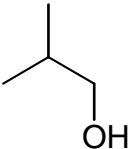
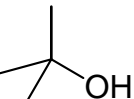
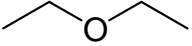
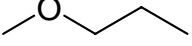
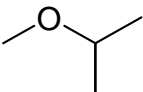
10 marks

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Question 3		
	Answer	Marks
a)	$(C_aH_bN_cO_d \rightarrow a CO_2 + b/2 H_2O + c/2 N_2)$ $d = 2a + b/2$ <i>Award 1 mark for 2a and 1 mark for b/2</i>	2
b)	O balance = $\frac{16 \times (d - 2a - b/2)}{(12a + b + 14c + 16d)} \times 100\%$ <i>Allow 1 mark if correct but 'x 100' missing</i>	2
c)	O balance = $- [100 \times (3 \times 16) / 222.14] = -21.6\%$ <i>Award 1 mark for correct sign, 1 mark for magnitude.</i> <i>Allow ecf (both number and sign) from expression in (a).</i>	2
d)	$C_7H_5N_3O_6 \rightarrow 3 CO + 3 C + CO_2 + 3/2 H_2 + 3/2 N_2 + H_2O$ <i>Allow 1 mark if equation is incorrect but correct products are shown and equation is balanced.</i>	2
e)	Amount of gas = 1/24 mol. Molar ratio TNT: gas = 1:7 [<i>Allow ecf from (d)</i>] Amount of TNT = $1/7 \times 1/24 \text{ mol} = 1/168 \text{ mol} = 0.0060 \text{ mol}$ Mass of TNT = $227.14 \text{ g mol}^{-1} \times 1/168 \text{ mol} = 1.35 \text{ g}$ <i>Award 2 marks for correct answer (with ecf if necessary) without working.</i>	2

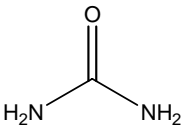
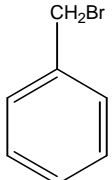
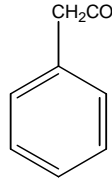
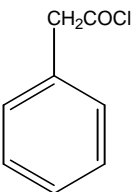
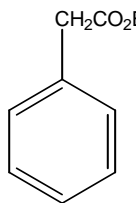
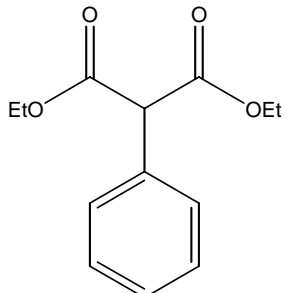
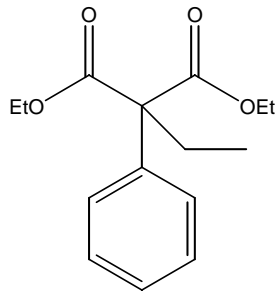
10 marks

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Question 4		
	Answer	Marks
	<p>Award 1 mark for any clear representation (even if not skeletal) for each correct structure in the correct box. Award an additional mark (for structures 1-4) if the name matches the structure drawn.</p> <p>If incorrect structure is drawn in a box (e.g. butan-2-ol is drawn in box 1) but name matches the structure drawn – award 1 mark.</p> <p>See additional note below.</p>	
	<p>1 = butan-1-ol</p> 	1 1
	<p>2 = butan-2-ol</p> 	1 1
	<p>3 = 2-methylpropan-1-ol [Initial '2' can be omitted]</p> 	1 1
	<p>4 = 2-methylpropan-2-ol [Initial '2' can be omitted]</p> 	1 1
	<p>5 =</p> 	1
	<p>6 =</p> 	1
	<p>7 =</p> 	1
	<p>Add 2 extra marks to candidate's total for this Q if all structures correctly drawn as skeletal. Award 1 additional mark for four or more structures correctly drawn as skeletal.</p>	2

13 marks

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Question 5		
	Answer	Marks
a)	<ul style="list-style-type: none"> • Moles A = $0.250/60 = 4.2 \times 10^{-3}$ • Moles C = moles $\text{CO}_2 = 0.178/44.01 = 4.0(4) \times 10^{-3}$ • Moles H = $2 \times \text{moles H}_2\text{O} = 2 \times (0.146/18.016) = 16.2(1) \times 10^{-3}$ • Moles N = moles NH_3 = moles $\text{HCl} = (40.8/1000) \times 0.200 = 8.16 \times 10^{-3}$ • Mass of C + H + N in sample of A = $(4.04 \times 10^{-3} \times 12.01) + (16.21 \times 10^{-3} \times 1.008) + (8.16 \times 10^{-3} \times 14.01) = 0.179(2)\text{g}$ • Mass of O in A = $0.250 - 0.179(2) = 0.071\text{g}$ • Moles of O in A = $0.071/16 = 4.4 \times 10^{-3}$ • This gives empirical formula of A = $\text{CH}_4\text{N}_2\text{O}$ • $M_r(\text{A}) = 60$, so molecular formula of A is also $\text{CH}_4\text{N}_2\text{O}$ • [Or .. $\text{CH}_4\text{N}_2 = 44$, $M_r(\text{A}) = 60$; molecular formula of A = $\text{CH}_4\text{N}_2\text{O}$] <p><i>1 mark for calculating moles A, C and H; 1 mark for calculating moles N; 1 mark for deducing oxygen as missing element; 1 mark for final formula</i></p>	4
b)	<p>A:</p>  <p>B:</p>  <p>C:</p>  <p>D:</p>  <p>E:</p>  <p>F:</p>  <p>G:</p>  <p><i>Allow any clear representation of correct structures. Award 1 mark for each correct structure</i></p>	7
11 marks		

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