

Cambridge  
International  
AS & A Level

**Cambridge International Examinations**  
Cambridge International Advanced Subsidiary and Advanced Level

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**CHEMISTRY**

**9701/04**

Paper 4 A Level Structured Questions

**For Examination from 2016**

SPECIMEN MARK SCHEME

**2 hours**

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**MAXIMUM MARK: 100**

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This document consists of **8** printed pages.



**2**

## Mark scheme abbreviations

<b>;</b>	separates marking points
<b>/</b>	alternative answers for the same point
<b>R</b>	reject
<b>A</b>	accept (for answers correctly cued by the question, or by extra guidance)
<b>AW</b>	alternative wording (where responses vary more than usual)
<b><u>underline</u></b>	actual word given must be used by candidate (grammatical variants excepted)
<b>max</b>	indicates the maximum number of marks that can be given
<b>ora</b>	or reverse argument
<b>mp</b>	marking point (with relevant number)
<b>ecf</b>	error carried forward
<b>I</b>	ignore
<b>AVP</b>	Alternative valid point (examples given as guidance)

3

- 1 (a) (i) carbonates become more stable down the Group/higher decomposition temperature (1)  
cation/ $M^{2+}$  radius/size increases down the group/ $M^{2+}$  charge density decreases (1)  
anion/carbonate ion/ $CO_3^{2-}$  suffers less polarisation/distortion (1) [3]
- (ii) ionic radii quoted:  $Ca^{2+}$ : 0.099 nm,  $Zn^{2+}$ : 0.074 nm,  $Pb^{2+}$ : 0.120 nm (1)  
thus we expect  $ZnCO_3$  to be less stable, but  $PbCO_3$  to be more stable (1) [2]
- if candidate states  $PbCO_3$  is more stable than  $ZnCO_3$  (or converse) with no reference to  $CaCO_3$  (1)
- (b) hydroxides become more soluble down the group (1)  
both lattice energy and hydration decrease (1)  
but lattice energy decreases more than hydration energy  
so enthalpy of solution become less endothermic (1) [4]

[Total: 9]

2 (a)

	$[CH_3CHO]$ /mol dm <sup>-3</sup>	$[CH_3OH]$ /mol dm <sup>-3</sup>	$[H^+]$ /mol dm <sup>-3</sup>	[acetal A] /mol dm <sup>-3</sup>	$[H_2O]$ /mol dm <sup>-3</sup>
at start	0.20	0.10	0.05	0.00	0.00
atequilibrium	(0.20 – x)	(0.10 – 2x)	0.05	x	x
atequilibrium	0.175	0.05	0.05	0.025	0.025

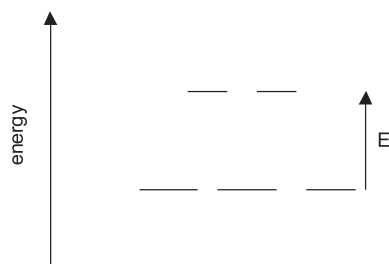
- (i) 3 values in second row  $3 \times (1)$  [3]
- (ii) 4 values in third row  $4 \times (1)$  [4]
- (iii)  $K_c = \frac{[acetal A][H_2O]}{[CH_3CHO][CH_3OH]^2}$  (1)  
units = mol<sup>-1</sup>dm<sup>3</sup> (1) [2]
- (iv)  $K_c = 0.025^2 / (0.175 \times 0.05^2) = 1.4(3)(mol^{-1}dm^3)$  [1]
- (b) (i) Order w.r.t  $[CH_3CHO] = 1$   
Order w.r.t.  $[CH_3OH] = 1$   
Order w.r.t  $[H^+] = 1$  [3]
- (ii) rate =  $k[CH_3CHO][CH_3OH][H^+]$  [1]
- (iii) units = mol<sup>-2</sup> dm<sup>6</sup> s<sup>-1</sup> [1]
- (iv) rate will be  $2 \times 4 = 8$  times as fast as reaction 1 (relative rate = 8) [1]

[Total: 16]

4

- 3 (a) Fe [Ar] 4s<sup>2</sup> 3d<sup>6</sup>  
Fe<sup>3+</sup> [Ar] 3d<sup>5</sup> [1]

(b) (i)



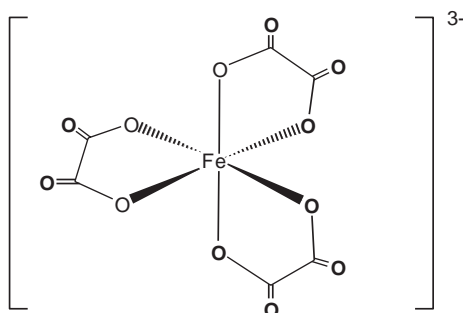
Marks are for 5 degenerate orbitals (1)  
and 3:2 split (1)

- (ii) colour due to the absorption of visible light (**NOT** emitted light) (1)  
E = hf or photon's energy = E in above diagram (1)  
electron promoted from lower to higher orbital (1) [3]
- (iii) size of ΔE depends on the ligand (1)  
as ΔE changes, so does f in E = hf (1) [2]

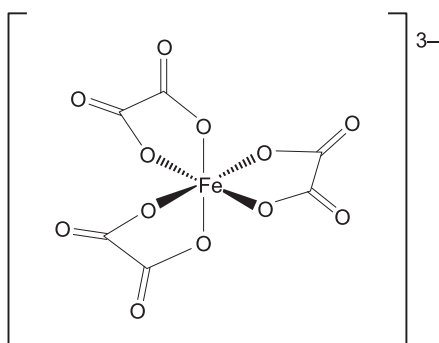
- (c) (i) O.N. (carbon) = +3 [1]

- (ii) O.N. = +3 [1]

(iii)



[1]



[1]

- (iv)  $2 \text{K}_3\text{Fe}(\text{C}_2\text{O}_4)_3 \rightarrow 3 \text{K}_2\text{C}_2\text{O}_4 + 2 \text{FeC}_2\text{O}_4 + 2 \text{CO}_2$   
or  $\text{K}_3\text{Fe}(\text{C}_2\text{O}_4)_3 \rightarrow \underline{3/2} \text{K}_2\text{C}_2\text{O}_4 + \text{FeC}_2\text{O}_4 + \text{CO}_2$

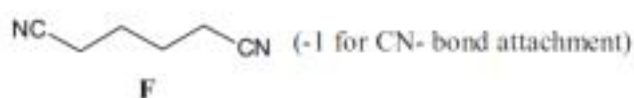
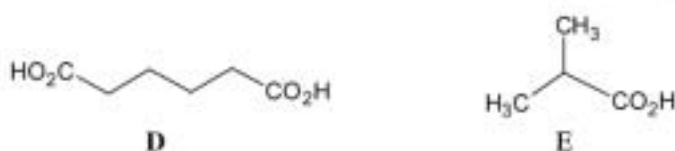
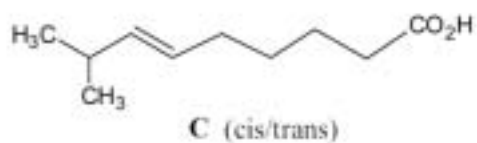
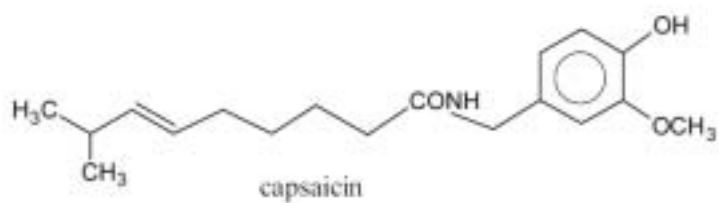
[1]

[Total: 13]

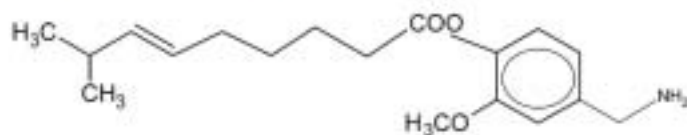
5

- 4 (a)  $K_2Cr_2O_7 + H^+ + \text{heat under reflux}$  [1]
- (b) nucleophilic substitution [1]
- (c) heat under reflux + aqueous  $HCl$  [1]
- (d) alkene [1]
- (e) amide or ester [1]
- (f)

(f)



alternative structure for capsaicin



ecf 5 × [1]

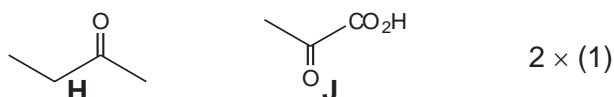
[5]

[Total: 10]

6

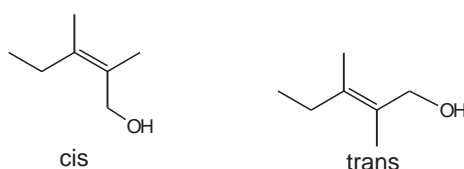
- 5 (a) (i) C = C double bonds / alkenes [1]
- (ii) –OH groups / accept alcohols or acids [1]
- (iii) CH<sub>3</sub>CO– or CH<sub>3</sub>CH(OH)– groups [1]
- (iv) carbonyl, >C=O, groups / accept aldehydes and ketones [1]

(b)



[2]

(c) isomers of **G**



correct structure (excluding stereochemistry) (1)

cis and trans drawn correctly (1)

type of isomerism is **cis-trans or geometrical isomerism** (1)

[3]

[Total: 9]

- 6 (a) (i) **A** is Cl<sub>2</sub>/chlorine (1)
- B** is NaCl or HCl or Cl<sup>–</sup> [or words] (1)
- C** is salt bridge or KCl/ KNO<sub>3</sub> (1)
- D** is platinum/Pt (1)
- E** is Fe<sup>2+</sup> + Fe<sup>3+</sup> or mixture of Fe(II) + Fe(III) salts (1) [5]

- (ii)  $E^{\circ} = E^{\circ}_{\text{R}} - E^{\circ}_{\text{L}} = 0.77 - 1.36 = (-)0.59$  (V) (ignore sign) (1)
- (since R.H. electrode is negative electrons flow (from right) **to left** or to the chlorine electrode or anticlockwise or from (beaker) **E** to (beaker) **B** (1) [2]

- (b) (i)  $\Delta H^{\circ} = 3 \times (-167.2) + (-48.5) - (-399.5)$  (1)
- $= -150.6$  or **151** (kJ mol<sup>–1</sup>) (1)
- correct answer only (2) [2]

- (ii)  $2\text{Fe}^{3+} + \text{Cu} \rightarrow 2\text{Fe}^{2+} + \text{Cu}^{2+}$  (1)
- (or molecular:  $2\text{FeCl}_3 + \text{Cu} \rightarrow 2\text{FeCl}_2 + \text{CuCl}_2$ )
- $E^{\circ} = 0.77 - 0.34 = (+) 0.43$  (V) (1) [2]
- (no mark for –0.43V)

[Total: 11]

7

7 (a)

process	sign of $\Delta S$
$\text{NaBr(s)} + (\text{aq}) \rightarrow \text{NaBr(aq)}$	+
$\text{H}_2\text{O(l)} \rightarrow \text{H}_2\text{O(g)}$	+
$2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O(g)}$	-
$\text{CoCl}_2(\text{s}) + 6\text{H}_2\text{O(l)} \rightarrow \text{CoCl}_2 \cdot 6\text{H}_2\text{O(s)}$	-

2 correct, (1) mark

4 correct, (2) marks

[2]

(b)  $\Delta S^\circ = (214 \times 2) + (70 \times 3) - (161 \times 1) - (205 \times 3)$   
 $= -138 \text{ J K}^{-1} \text{ mol}^{-1}$

[2]

(c) As temperature increases  $T\Delta S$  is more negative or  $-T\Delta S$  increases (1)  
 At high temperature  $T\Delta S$  is more negative than  $\Delta H$  (so  $\Delta G$  is positive) (1)

[2]

(d) the reaction is feasible,  $\Delta G$  is negative so  
 $T > \Delta H/T\Delta S$  or use of  $T = \Delta H/T\Delta S$  (1)

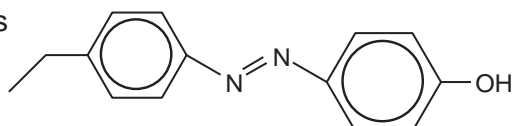
$T = 178000/159$  (1)

$T = 1119.5 \text{ K}$  units required or  $T > 1120 \text{ K}$  (1)

[3]

[Total: 9]

8 (a) X is



allow  $-\text{N}_2-$  and  $-\text{ONa}$

[1]

- (b) reaction I:  $\text{Cl}_2 + \text{light}$  (1) (not aq)  
 reaction II:  $\text{Br}_2 + \text{AlBr}_3$  or  $\text{Fe}$  or  $\text{FeBr}_3$  (1) (not aq)  
 reaction III:  $\text{NaOH}$ , heat in ethanol (1) (allow aqueous EtOH)  
 reaction IV:  $\text{HNO}_3 + \text{H}_2\text{SO}_4$  (1) conc and  $60^\circ\text{C}$  (1)  
 reaction V:  $\text{KMnO}_4 + \text{H}^+/\text{OH}^- + \text{heat}$  (1)  
 reaction VI:  $\text{Sn} + \text{HCl}$  (1)  
 reaction VII:  $\text{HNO}_2 + \text{HCl} < 10^\circ\text{C}$  (1)

[8]

[Total: 9]

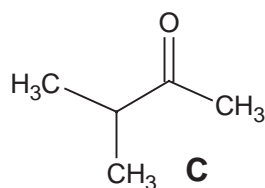
8

9 (a) time for a component between injection and travelling to the detector [1]

(b) (i) No. of carbon atoms present in J is  $\frac{100 \times 1.3}{1.1 \times 23.5} = 5$  carbons (must show working) [1]

(ii) 4 different carbon environments (1)  
 $\delta$  210 is C = O carbon (1)  
 $\delta$  15-45 are alkyl carbons/C–C (1) [3]

(iii) Y is



(1)

Isomer A would show 5 absorptions/peaks (1)

Isomer B would only show 3 absorptions/peaks (1) [3]

[Total: 8]

10 (a) (many) monomers add together to form a polymer and small molecule (such as H<sub>2</sub>O, HCl) [1]

(b)

bonding type	secondary structure	tertiary structure
hydrogen bonding	✓	✓
ionic bonding		✓
van der Waals'		✓

2 correct [1]; all correct [2] [2]

(c) (i) pH of the buffer solution [1]

(ii)

amino acid	Identity of amino acid (any one of)
A	Asp, Glu
B	Gly, Val, Phe, Ala
C	Lys

2 correct [1]; 3 correct [2] [2]

[Total: 6]