Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/04**

Paper 4 A Level Structured Questions **For Examination from 2016**

SPECIMEN MARK SCHEME

2 hours

MAXIMUM MARK: 100

CAMBRIDGE International Examinations

Mark scheme abbreviations

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

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^{-3}	$[CH_3OH]$ /mol dm^{-3}	[H*] /mol dm^{-3}	[acetal **A**] /mol dm^{-3}	$[H_2O]$ /mol dm^{-3}
at start	0.20	0.10	0.05	0.00	0.00
at equilibrium	(0.20 – **x**)	**(0.10 – 2x)**	**0.05**	**x**	**x**
at equilibrium	**0.175**	**0.05**	**0.05**	0.025	**0.025**

(i) 3 values in second row 3 × (1) [3]

(ii) 4 values in third row 4 × (1) [4]

(iii) K_c = {[acetal **A**][H_2O]}/{[CH_3CHO][CH_3OH]^2} (1)
units = $mol^{-1}dm^3$ (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]

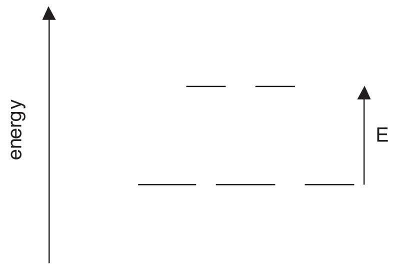
(iii) units = $mol^{-2}\ dm^6\ s^{-1}$ [1]

(iv) rate will be 2 × 4 = 8 times as fast as reaction 1 (relative rate = 8) [1]

[Total: 16]

3 **(a)** Fe [Ar] $4s^2$ $3d^6$
Fe^{3+} [Ar] $3d^5$ [1]

(b) **(i)**



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

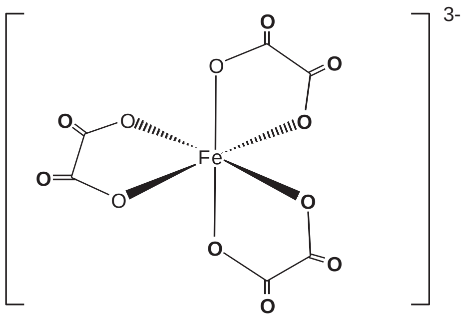
(ii) colour due to the absorption of visible light (**NOT** emitted light) (1)
E = hf or photon's energy = E in above diagram (1)
electron promoted from lower to higher orbital (1) [3]

(iii) size of ΔE depends on the ligand (1)
as ΔE changes, so does f in E = hf (1) [2]

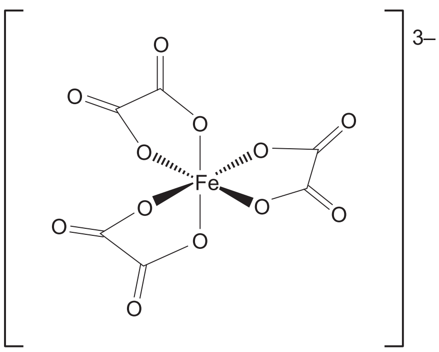
(c) **(i)** O.N. (carbon) = +3 [1]

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

(iii)



[1]



[1]

(iv) **2** $K_3Fe(C_2O_4)3 \rightarrow$ **3** $K_2C_2O_4$ + **2** FeC_2O_4 + **2** CO_2
or $K_3Fe(C_2O_4)_3 \rightarrow$ **3/2** $K_2C_2O_4 + FeC_2O_4 + CO_2$

[1]

[Total: 13]

4 **(a)** $K_2Cr_2O_7$ + H^+ + heat under reflux [1]

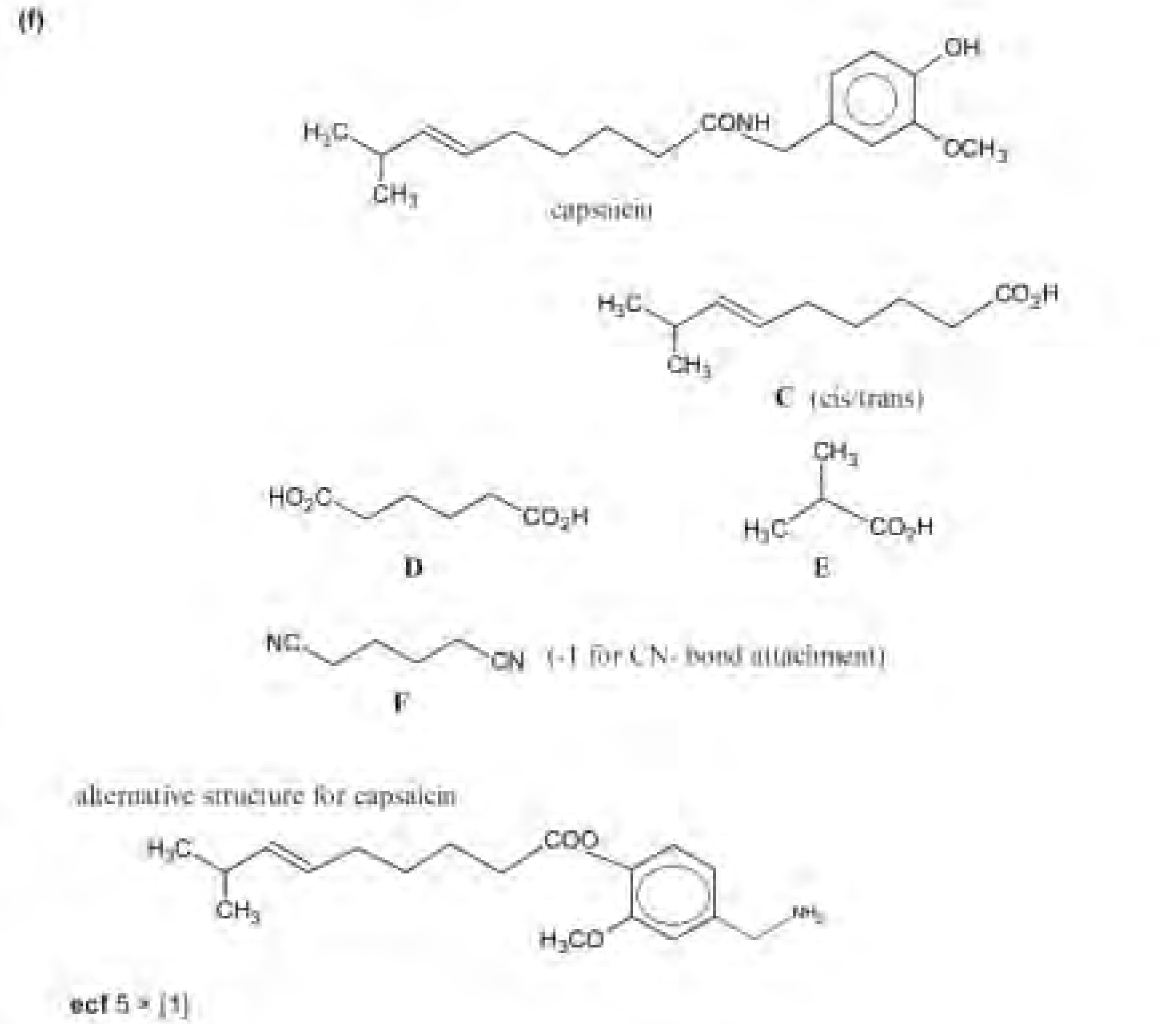
(b) nucleophilic substitution [1]

(c) heat under reflux + aqueous HCl [1]

(d) alkene [1]

(e) amide or ester [1]

(f)



[5]

[Total: 10]

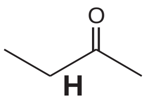
5 (a) (i) C = C double bonds / alkenes [1]

(ii) –OH groups / accept alcohols or acids [1]

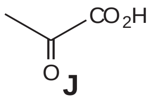
(iii) CH_3CO– or $CH_3CH(OH)$– groups [1]

(iv) carbonyl, >C=0, groups / accept aldehydes <u>and</u> ketones [1]

(b)



H

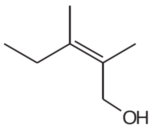


J

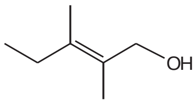
2 × (1)

[2]

(c) isomers of **G**



cis



trans

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_2/chlorine (1)
B is NaC*l* *or* HC*l* *or* Cl^- [or words] (1)
C is salt bridge or KC*l*/ KNO_3 (1)
D is platinum/Pt (1)
E is Fe^{2+} + Fe^{3+} or mixture of Fe(II) + Fe(III) salts (1) [5]

(ii) $E^{\ominus} = E^{\ominus}_R - E^{\ominus}_L = 0.77 - 1.36 = (-)$**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) $\Delta H^{\ominus} = 3 \times (-167.2) + (-48.5) - (-399.5)$ (1)
= –**150.6** *or* **151** (kJ mol^{-1}) (1)
correct answer only (2) [2]

(ii) $2Fe^{3+} + Cu \rightarrow 2Fe^{2+} + Cu^{2+}$ (1)
(*or* molecular: $2FeCl_3 + Cu \rightarrow 2FeCl_2 + CuCl_2$)
$E^{\ominus} = 0.77 - 0.34 = (+)$ **0.43** (V) (1) [2]
(no mark for –0.43V)

[Total: 11]

7 (a)

process	**sign of ΔS**
$NaBr(s) + (aq) \rightarrow NaBr(aq)$	+
$H_2O(l) \rightarrow H_2O(g)$	+
$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$	–
$CoCl_2(s) + 6H_2O(l) \rightarrow CoCl_2.6H_2O(s)$	–

2 correct, (1) mark
4 correct, (2) marks [2]

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

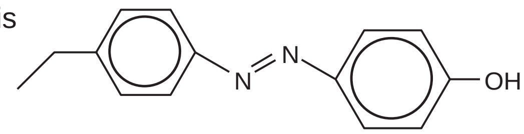
(c) As temperature increases $T\Delta S$ is more negative or $-T\Delta S$ increases (1)
At high temperature $T\Delta S$ is more negative than ΔH (so ΔG is positive) (1) [2]

(d) the reaction is feasible, ΔG 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 K units required or T>1120 K (1) [3]

[Total: 9]

8 (a) **X** is



allow $-N_2-$ and –ONa [1]

(b) reaction **I**: $\underline{C}l_2$ + light(1) (<u>not</u> aq)
reaction **II**: $Br_2 + AlBr_3$ *or* Fe *or* $FeBr_3$ (1) (<u>not</u> aq)
reaction **III**: NaOH, heat in ethanol (1) (allow aqueous EtOH)
reaction **IV**: $HNO_3 + H_2SO_4$ (1) conc and 60 °C (1)
reaction **V**: $KMnO_4 + H^+/OH^-$ + heat (1)
reaction **VI**: Sn + HCl (1)
reaction **VII**: HNO_2 + HCl < 10 °C (1) [8]

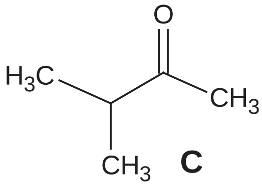
[Total: 9]

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)
δ 210 is C = O carbon (1)
δ 15-45 are alkyl carbons/C–C (1) [3]

(iii) **Y** is



C

(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_2O, 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]