UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the October/November 2011 question paper

for the guidance of teachers

9701 CHEMISTRY

9701/41 Paper 4 (A2 Structured Questions), maximum raw mark 100

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1 **(a)** **(i)** *either* burn *or* shine light/uv on mixture of H_2 + Cl_2 *but* NOT heat [1]

(ii) red/orange/brown colour of bromine decolourises/disappears
steamy/misty/white fumes produced
container gets warm/hot [2]

(iii) H-H = 436   Cl-Cl = 244   H-Cl = 431

ΔH = 436 + 244 – 2(431) = –182 kJ mol^{-1} [2]

H-H = 436   Br-Br = 193   H-Br = 366

ΔH = 436 + 193 – 2(366) = –103 kJ mol^{-1} [2]

(iv) H-Br bond is weaker than the H-Cl bond – allow converse. [1]
[8]

(b) **(i)** light [1]

(ii) bonds broken = C-H & I-I = 410 + 151 = 561
bonds made = C-I & H-I = 240 + 299 = 539
ΔH = 551 – 539 = +22 kJ mol^{-1} [2]

(iii) The overall reaction is endothermic *or* no strong bonds/only weak bonds are formed *or* high E_{act} [1]
[4]

(c) **(i)** homolytic fission is the breaking of a bond to form (two) radicals/neutral species/odd-electron species [1]

(ii) •CH_2Cl [1]
the C-Br bond is the weakest or needs least energy to break/breaks most easily [1]
[3]

(d)

4 structures: [2]
2 or 3 structures: [1]

Correct chiral atom identified [1]
[3]

[Total: 18]

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2 **(a)** **(i)** Order w.r.t. $[CH_3CHO]$ = 1 [1]
Order w.r.t. $[CH_3OH]$ = 1 [1]
Order w.r.t. $[H^+]$ = 1 [1]

(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]
[6]

(b)

	$[CH_3CHO]$ /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 x [1]

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

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

(iv) K_c = $0.025^2/(0.175 \times 0.05^2)$ = **1.4(3)** ($mol^{-1}\ dm^3$) [1]
[max 9]

[Total: 15]

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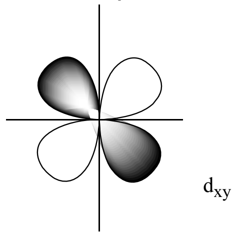
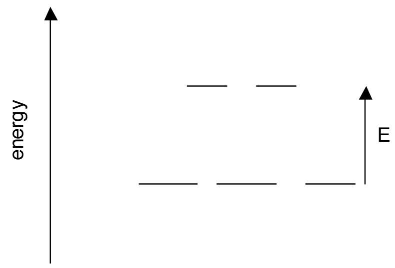
3 **(a)** for example.... also allow d_{z2}



shape (4 lobes) [1]
correct label e.g. d_{xy} [1]
[2]

(b) **(i)**



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

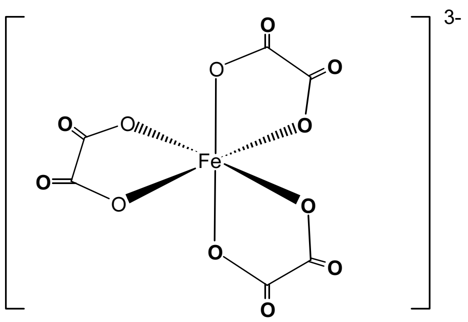
(ii) colour due to the absorption of light NOT emitted light [1]
E = hf *or* photon's energy = E in above diagram [1]
electron promoted from lower to higher orbital [1]

size of ΔE depends on the ligand [1]
as ΔE changes, so does f in E = hf [1]
[7]

(c) **(i)** O.N.(carbon) = +3 (4 × (–2) + 2x = –2, thus 2x = +6) [1]

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

(iii)



[2]

(iv) **<u>2</u>** $K_3Fe(C_2O_4)_3 \rightarrow$ **<u>3</u>** $K_2C_2O_4$ + **<u>2</u>** FeC_2O_4 + **<u>2</u>** CO_2 [2]
Or $K_3Fe(C_2O_4)_3 \rightarrow$ **<u>3/2</u>** $K_2C_2O_4 + FeC_2O_4 + CO_2$

[max 5]

[Total: 14]

4 **(a)** **(i)** $C_2H_5NH_2 + HA \rightarrow C_2H_5NH_3^+ + A^-$ (HA can be H_2O, HCl etc.) [1]
Allow $\rightleftharpoons$ instead of arrow

(ii)

most basic		least basic
ethylamine	**ammonia**	**phenylamine**

[1]

(iii) ethylamine > NH_3 due to electron-donating ethyl/alkyl group [1]
phenylamine < NH_3 due to delocalisation of lone pair over ring [1]
[4]

(b) **(i)** $C_6H_5OH + OH^- \rightarrow C_6H_5O^- + H_2O$ (*or* with $Na^+/H_2O/A^-$) [1]

(ii) pKa of nitrophenol is smaller/K_a is larger because it's a stronger acid/dissociates more than phenol [1]
stronger because the anionic charge is spread out moreover the NO_2 group *or* NO_2 is electron-withdrawing [1]

(iii) pKa = 1.0 [1]

(iv) Nitro group increases acidity / electron-withdrawing groups increase acidity [1]
[5]

(c) **(i)** **B** is phenyldiazonium cation, $C_6H_5–N^+\equiv N$ [1]

(ii)

reaction	reagent(s)	conditions
Step 1	**$NaNO_2$ + HCl or HNO_2** [1]	**T < 10°C** [1]
Step 2	**H_2O / aq**	**heat/boil/T > 10°** (both) [1]
Step 3	**HNO_3 NB HNO_3(aq) OK for both**	**dilute** (both) [1]

[4]
[5]

[Total: 14]

5 **(a)** **(i)** C=C double bonds / alkenes

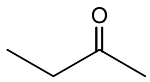
(ii) –OH groups / accept alcohols or acids

(iii) CH_3CO– or $CH_3CH(OH)$– groups

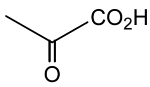
(iv) carbonyl, >C=O, groups / accept aldehydes <u>and</u> ketones 4 × [1]

[4]

(b)



D

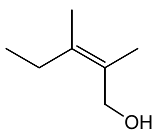


E

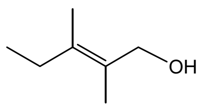
2 × [1]

[2]

(c) isomers of **C**



cis



trans

correct structure (excl. stereochemistry) [1]
cis and trans drawn correctly [1]
type of isomerism is **cis-trans *or* geometrical isomerism** [1]

[3]

[Total: 9]

6 **(a)** **(i)** $2H_2NCH_2CO_2H \rightarrow H_2NCH_2CONHCH_2CO_2H + H_2O$ [1]

(ii) Skeletal formula required [1]

[2]

(b) **(i)** α helix [1]
β pleated sheet [1]

(ii) **Students should choose one of the structures below**

For α helix:
Need to show a helix with C=O - - - H-N between turns

For β pleated sheet:
Need to show two parallel 'zig-zag' strands with C=O - - - H-N between them

Whichever is chosen, overall structure [1] position of H bonds [1]

[4]

(c)

amino acid residue 1	amino acid residue 2	type of bonding
$–HNCH(CH_2CH_2CH_2CH_2NH_2)CO–$	$HNCH(CH_2CH_2CO_2H)CO–$	Ionic bonds or hydrogen bonds
$–HNCH(CH_3)CO–$	$–HNCH(CH_3)CO–$	van der Waals'
$–HNCH(CH_2SH)CO–$	$–HNCH(CH_2SH)CO–$	Disulfide bonds
$–HNCH(CH_2OH)CO–$	$–HNCH(CH_2CO_2H)CO–$	Hydrogen bonds

[4]

[Total: 10]

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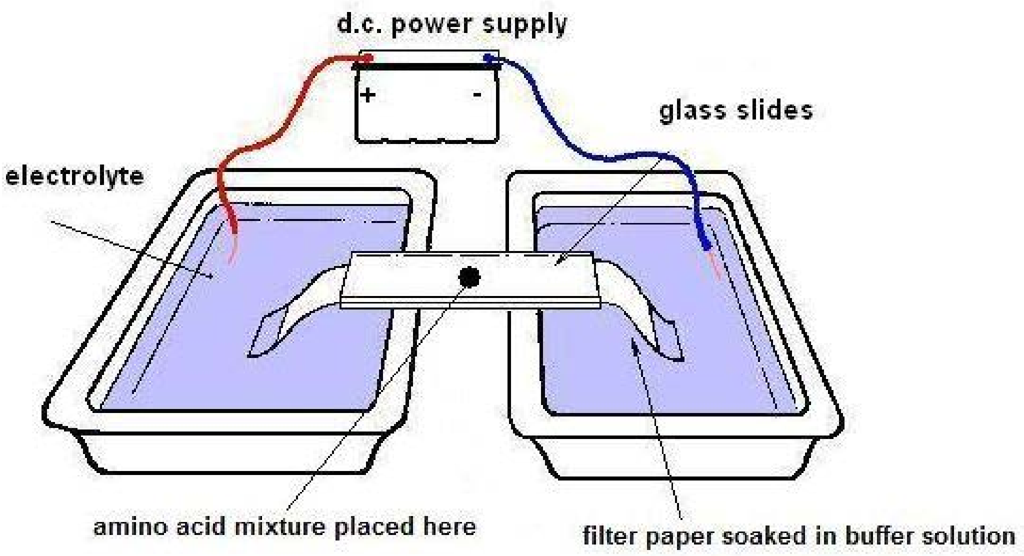
7 **(a)** Sketch and label the apparatus used to carry out electrophoresis e.g



Marks: power supply / electrolyte + filter paper / buffer / acid mixture central — 4 × [1]

[4]

(b) **(i)** pH of the buffer [1]
Charge on the amino acid species [1]

(ii) Size of the amino acid species / M_r [1]
Voltage applied [1]
Magnitude of the charge (on the amino acid species) [1]
Temperature [1]
(max 3)
[max 3]

(c) **(i)** They have insufficient electron density / only one electron [1]
(ii) Sulfur [1]
because it has the greatest atomic number / number of electrons [1]
[3]

[Total: 10]

8 **(a)**

traditional material	modern polymer used
Paper/cardboard/wood/leaves hessian/hemp/jute steel/aluminium	PVC in packaging
Cotton/wool/linen	*Terylene* in fabrics
Glass/china/porcelain/earthenware metal/leather	Polycarbonate bottle

3 → 2 marks, 2 → 1 mark
[2]

(b) Reasons: Plastics/polymers pollute the environment for a long time do not decompose/ biodegrade quickly [1]
They are mainly produced from oil [1]
Produce toxic gases on burning [1]
max two

Strategy 1: Recycle polymer waste / use renewable resources [1]
Strategy 2: Develop biodegradable polymers [1]
[max 3]

(c) PVC [1]
Combustion would produce HC*l* / dioxins as a pollutant [1]
or
nylon/acrylic [1]
Combustion would produce HCN [1]
[2]

(d) **(i)** Polythene (or other addition polymer) [1]

(ii) Addition polymerisation [1]

The polymer chains don't have strong bonds between them – easy to melt [1]
Could be answered with a suitable diagram **[3]**

[Total: 10]

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