CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the October/November 2012 series

9701 CHEMISTRY

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

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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1 **(a)** $SiCl_4$: **white** solid *or* **white/steamy** fumes

$SiCl_4 + 2H_2O \longrightarrow SiO_2 + 4HCl$

PCl_5: fizzes *or* white/steamy fumes [1]
$PCl_5 + 4H_2O \longrightarrow H_3PO_4 + 5HCl$ [1]

[4]

(b) **(i)** $MnO_4^- + 8H^+ + 5Fe^{2+} \longrightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$ [1]

(ii) 5 : 1

(iii) $n(MnO_4^-) = 0.02 \times 15/1000 = 3 \times 10^{-4}$ (mol) [1]

(iv) $n(Fe^{2+}) = 5 \times 3 \times 10^{-4} = 1.5 \times 10^{-3}$ (mol) ecf from **(i)** or **(ii)** [1]

(v) $[Fe^{2+}] = 1.5 \times 10^{-3} \times 1000/2.5 =$ **0.6** ($mol\ dm^{-3}$) ecf from **(iv)** [1]

(vi) In the original solution, there was 0.15 mol of Fe^{3+} in 100 cm^3.
In the partially-used solution, there is 0.06 mol of Fe^{2+} in 100 cm^3.

So remaining Fe^{3+} = 0.15 – 0.06 = 0.09 mol. ecf from **(v)** [1]

This can react with 0.045 mol of Cu, which = 0.045 × 63.5 = **2.86 g** of copper. ecf [1]

[6]

(c) bonds broken are Si-Si and Cl-Cl = 222 + 244 = 466 $kJ\ mol^{-1}$
bonds formed are 2 × Si-Cl = 2 × 359 = 718 $kJ\ mol^{-1}$
ΔH = **<u>–252</u>** $kJ\ mol^{-1}$ [2]

[2]

(d) **(i)** $Ca_2Si + \mathbf{6}H_2O \longrightarrow \mathbf{2}Ca(OH)_2 + SiO_2 + \mathbf{4}H_2$ [1]

(ii) silcon has been oxidised **<u>AND</u>** hydrogen has been reduced [1]

[2]

[Total: 14]

2 (a) (i) **A** = $CuSO_4$
B = silver

(ii) salt bridge [1]
voltmeter [1]

[4]

(b) (i) 0.80 – 0.34 = **(+) 0.46 V** [1]

(ii) If E_{cell} = 0.17, this is 0.29 V less than the standard $E^{\ominus}$,
so $E_{\text{Ag electrode}}$ must = 0.80 – 0.29 = **0.51 V** [1]

(iii) 0.51 = 0.80 + 0.06log [Ag^+], so [Ag^+] = $10^{(-0.29/0.06)}$ = <u>**1.47 x 10^{-5}**</u> mol dm^{-3} ecf from **(ii)** [1]

[3]

(c) (i) $K_{sp} = [Ag^+]^2[SO_4^{2-}]$ [1]
units = $mol^3\,dm^{-9}$ ecf on K_{sp} [1]

(ii) $[SO_4^{2-}] = [Ag^+]/2$ $K_{sp} = (1.6 \times 10^{-2})^2 \times 0.8 \times 10^{-2}$ = <u>**2.05 × 10^{-6}**</u> ($mol^3\,dm^{-9}$) [1]

[3]

(d) AgC*l* white [1]
AgBr cream [1]
AgI yellow [1]

Solubility decreases down the group [1]

[4]

(e) solubility decreases down the group [1]
as M^{2+}/**ionic** radius increases [1]
both lattice energy <u>**and**</u> hydration(solvation) energy to decrease [1]
enthalpy change of solution becomes more endothermic [1]

[4]

[Total: 18]

3 (a) (i) heterogeneous: different states **<u>AND</u>** homogeneous: same state

(ii) the correct allocation of the terms *heterogeneous* and *homogeneous* to common catalysts [1]

example of heterogeneous, e.g. Fe (in the Haber process) <u>linked</u> to correct system [1]
equation, e.g. $N_2 + 3H_2 \longrightarrow 2NH_3$ [1]

how catalyst works, adsorption (onto the surface) [1]
ecf for non-iron catalyst

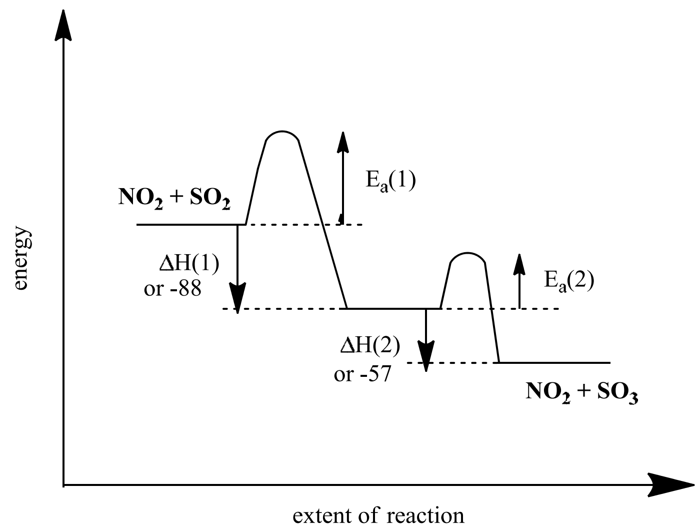
example of homogeneous, e.g. Fe^{3+} or Fe^{2+} (in $S_2O_8^{2-} + I^-$) linked to correct system [1]

equation, e.g. $S_2O_8^{2-} + 2I^- \longrightarrow 2SO_4^{2-} + I_2$ [1]

how catalyst works, e.g. $Fe^{3+} + I^- \longrightarrow Fe^{2+} + \frac{1}{2}I_2$ [1]
ecf for non-iron catalyst

[8]

(b)



both E_a shown, with $E_a(1) > E_a(2)$ [1]
both ΔH shown, with ΔH(1) > ΔH(2) [1]

[2]

[Total: 10]

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

(b) nucleophilic substitution [

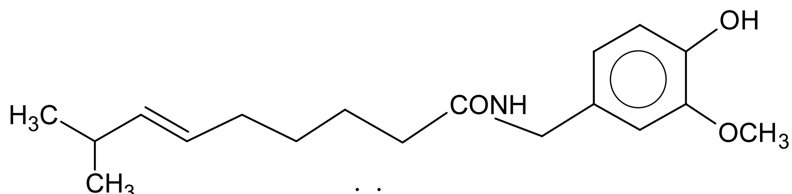
(c) heat under reflux + aqueous HC*l* [1]

(d) alkene [1]

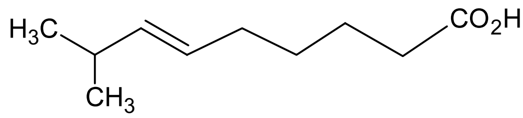
(e) amide *or* ester [1]

[5]

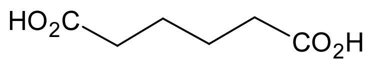
(f)



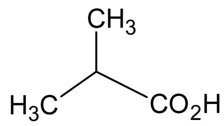
capsaicin



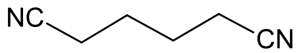
C (cis/trans)



D



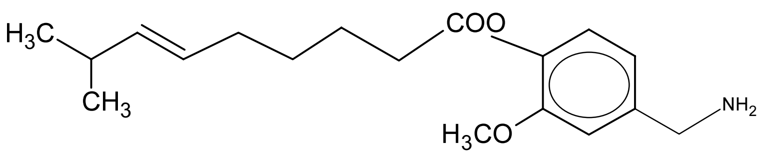
E



(-1 for CN- bond attachment)

F

alternative structure for capsaicin



ecf 5 × [1]

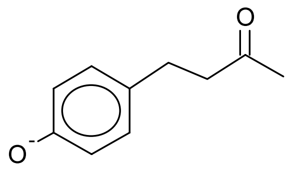
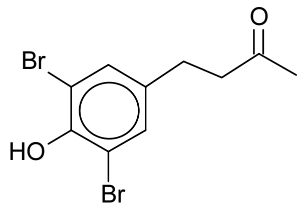
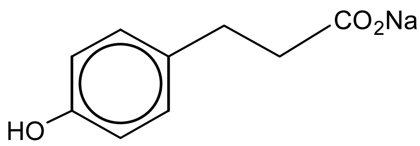
[5]

[Total: 10]

5 **(a)** phenol
ketone

[

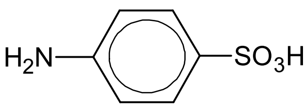
(b)

reagent	observation	structure of product	type of reaction
sodium metal	**effervescence /bubbles/fizzing**		*redox*
aqueous bromine	**decolourises** *or* **white ppt.**		*electrophilic substitution*
aqueous alkaline iodine	**yellow ppt.**		*oxidation*

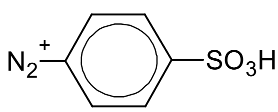
[2]

[8]

(c) **(i)**



J



K

[1] + [1]

(ii) step 1: $NaNO_2$ + HC*l* *or* HNO_2

at T < 10°C

step 2: (add **K** to a solution of **G)** in aqueous NaOH [1]

[5]

(d)

$$(CH_3CH_2CO_2H) \xrightarrow[\text{[1]}]{\text{SOC}l_2\text{/PC}l_5\text{/PC}l_3\text{ + heat}} CH_3CH_2COCl\ \text{[1]} \xrightarrow[\text{[1]}]{\text{add to G (in NaOH(aq))}} \textbf{L}$$

ecf from CH_3COOH **[3]**

[Total: 18]

Section B

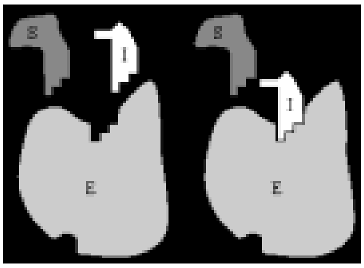
6 (a)

bonding	structure involved
disulfide bonds between parts of the chain	tertiary
hydrogen bonds in a β-pleated sheet	secondary
ionic bonds between parts of the chain	tertiary
peptide links between amino acids	primary

zero/one correct only→ [0], two correct only → [1], three correct only → [2] all four correct [3]

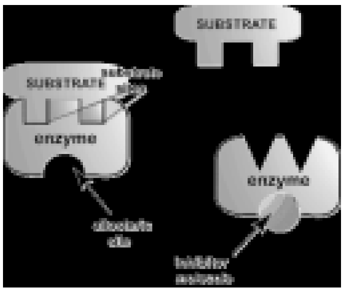
[3]

(b) labelled diagrams such as:



Competitive ***any two*** *from:*

- complementary shape to substrate / able to bind to active site of enzyme
- so preventing the substrate from binding / able to compete with substrate
- can be overcome by increasing [substrate] 2 × [1]

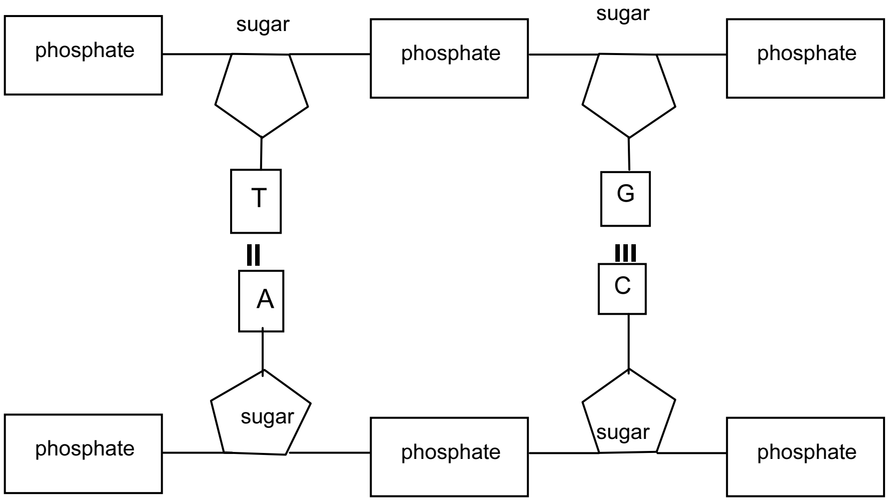


Non-competitive: ***any two*** *from:*

- binds elsewhere in the enzyme than active site / at an allosteric site
- this changes the shape of the active site
- cannot be removed by increasing [substrate] 2 × [1]

[4]

(c)



A and C **and** other strand correct [1]
H-bonds labelled [1]
adenine **AND** cytosine [1]

[3]

[Total: 10]

7 (a) (i) Electrophoresis [1]

(ii) Using a restriction enzyme. [1]

(iii) The phosphate group. [1]

[3]

(b) (i) **X labelled** correctly on diagram. [1]

(ii) Suspect 2 **AND** matches crime scene 1 or matches at least one crime scene. [1]

[2]

(c) **P** is $CH_3CO_2CH_2CH_3$

any <u>four</u> of:

- 3 different (proton) environments
- (M and M+1 data shows no of carbons present is) (100 × 0.22)/(1.1 × 5.1) = **4 carbons**
- the NMR spectrum shows 8 hydrogens leaving 32 mass unit or 2 oxygen ***or*** M_r = 88 **and** (molecular formula is) $C_4H_8O_2$
- 4 peaks/quartet (at 4.1) shows an adjacent 3H/CH_3
- 3 peaks/triplet (at 1.3) shows an adjacent 2H/CH_2
- (peak at) 2.0/singlet shows CH_3CO (group)
- (peak at) 4.1/quartet **and** 1.3/triplet shows presence of ethyl/CH_3CH_2 (group)

4 × [1]

[5]

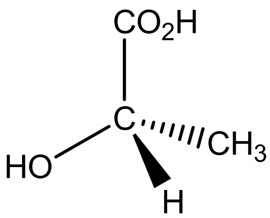
[Total: 10]

8 **(a)** **(i)** It could denature the enzyme ***or*** alter the 3D structure/tertiary structure/shape of active site. [1]

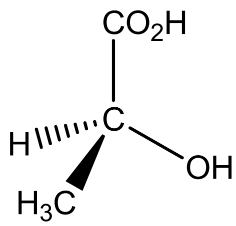
(ii) condensation [1]

[2]

(b)



OR



or correct diagram of the S isomer

[1]

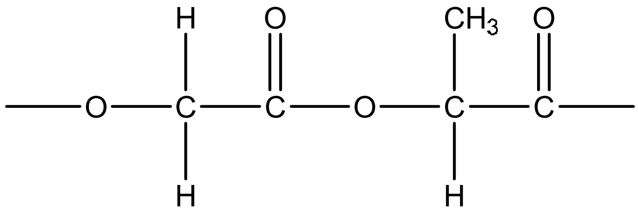
[1]

(c) **(i)** (Acid present would) hydrolyse the ester (linkage) [1]

(ii) (Hot water would) **soften** (the container) [1]

[2]

(d) (i)



ester linkage shown [1]
rest of repeat unit correct (ONE) [1]

(ii) van der Waals' from CH_3/methyl group [1]
permanent dipole-dipole from ester group [1]

(iii) Accept any sensible physical property suggestion e.g. different melting point *or* different density *or* different solubility. [1]

[5]

[Total: 10]