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

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

$SiCl_4 + 2H_2O \longrightarrow SiO_2 + 4HCl$ [1]

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 = $0.045 \times 63.5 =$ **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}
$\Delta H =$ **<u>–252</u>** kJ mol^{-1} [2]

[2]

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

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

[2]

[Total: 14]

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2 (a) (i) **A** = $CuSO_4$ [1]
B = silver [1]

(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 $E_{Ag\ electrode}$ must = 0.80 – 0.29 = **0.51 V** [1]

(iii) 0.51 = 0.80 + 0.06log $[Ag^+]$, so $[Ag^+] = 10^{(-0.29/0.06)}$ = **1.47 x 10^{-5}** 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) $[SO_4^{2-}] = [Ag^+]/2$ $K_{sp} = (1.6 \times 10^{-2})^2 \times 0.8 \times 10^{-2}$ = **2.05 × 10^{-6}** ($mol^3\,dm^{-9}$) [1]

[3]

(d) AgCl 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 **and** hydration(solvation) energy to decrease [1]
enthalpy change of solution becomes more endothermic [1]

[4]

[Total: 18]

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3 (a) (i) heterogeneous: different states **AND** homogeneous: same state [1]

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

example of heterogeneous, e.g. Fe (in the Haber process) linked 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

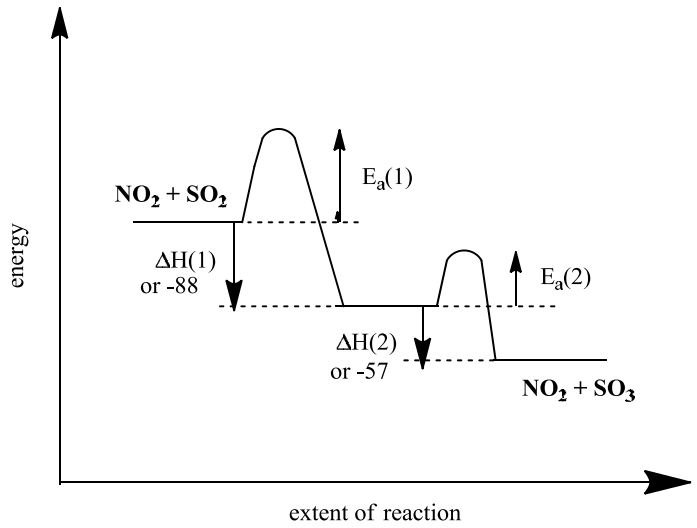
example of homogeneous, e.g. Fe^{3+} or Fe^{2+} (in $S_2O_8^{2-} + I^-$) linked to correct system [1]

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 $\Delta H(1) > \Delta H(2)$ [1]

[2]

[Total: 10]

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

(b) nucleophilic substitution [1]

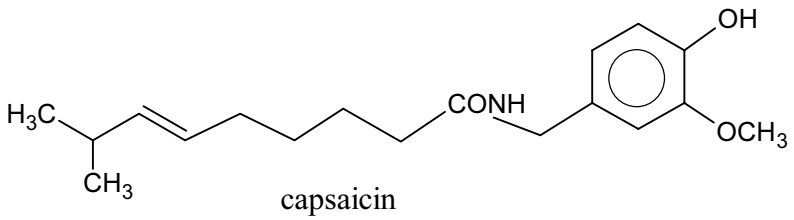
(c) heat under reflux + aqueous HC*l* [1]

(d) alkene [1]

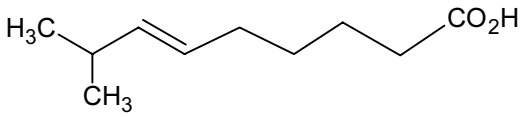
(e) amide *or* ester [1]

[5]

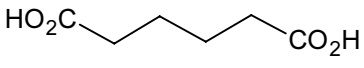
(f)



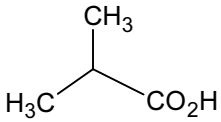
capsaicin



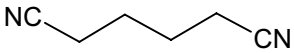
C (cis/trans)



D



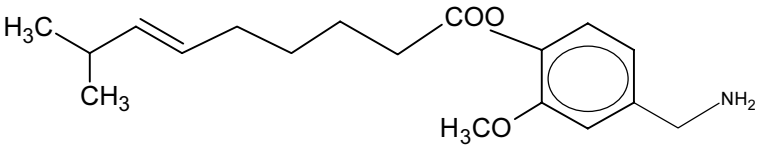
E



(-1 for CN- bond attachment)

F

alternative structure for capsaicin



ecf 5 × [1]

[5]

[Total: 10]

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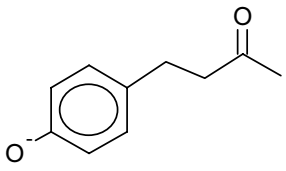
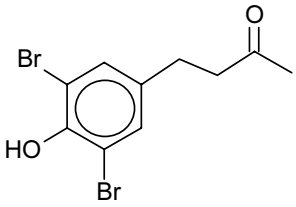
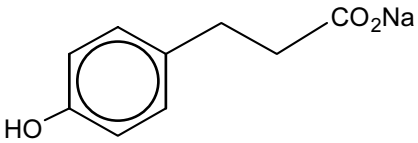
5 (a) phenol [1]
ketone [1]

[2]

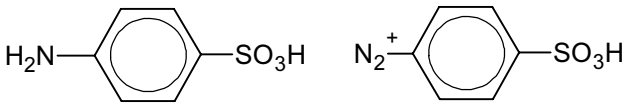
(b)

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]

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

at T < 10°C [1]

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

[5]

(d)

$$(CH_3CH_2CO_2H) \xrightarrow[[1]]{SOCl_2/PCl_5 /PCl_3 + \text{heat}} CH_3CH_2COCl \xrightarrow[[1]]{\text{add to } \mathbf{G} \text{ (in NaOH(aq))}} \mathbf{L}$$

[1]

ecf from CH_3COOH **[3]**

[Total: 18]

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Section B

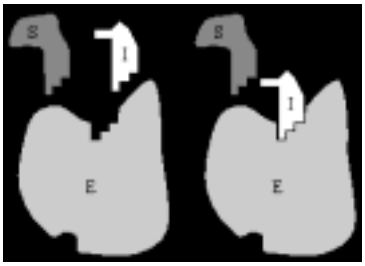
6 (a)

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]

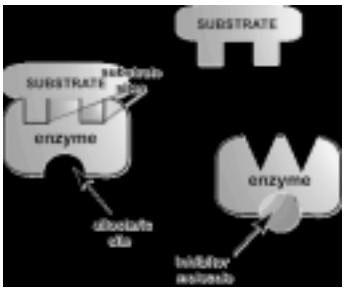
[3]

(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]

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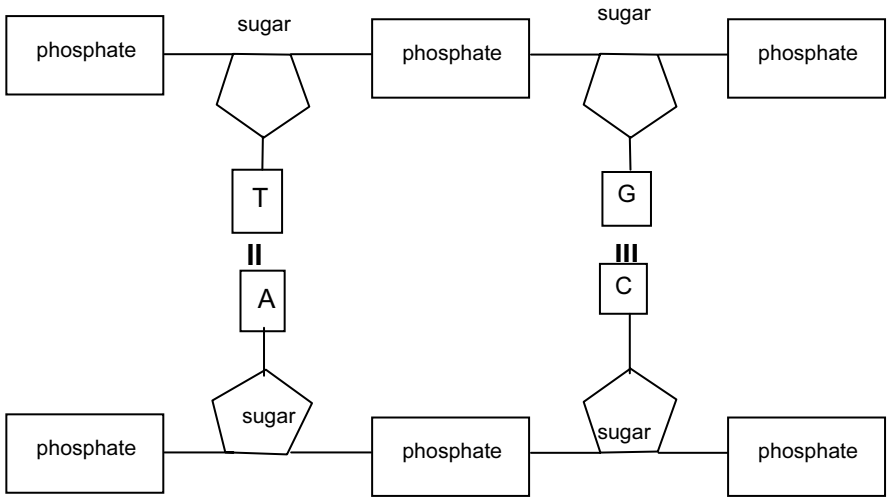
(c)



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]

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(c) **P** is $CH_3CO_2CH_2CH_3$ [1]

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]

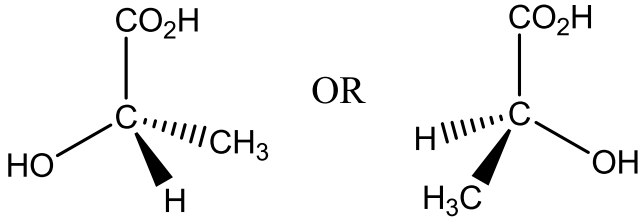
[Total: 10]

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 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]

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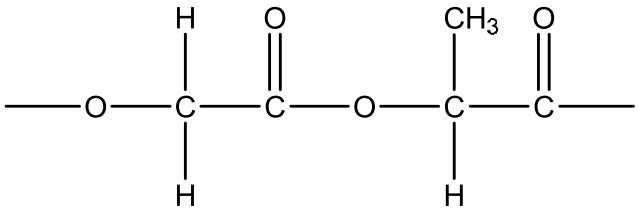
(d) (i)



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]

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