

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]



PCl_5 : fizzes or white/steamy fumes [1]



(b) (i) $\text{MnO}_4^- + 8\text{H}^+ + 5\text{Fe}^{2+} \longrightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O} + 5\text{Fe}^{3+}$ [1]

(ii) 5 : 1

(iii) $n(\text{MnO}_4^-) = 0.02 \times 15/1000 = 3 \times 10^{-4} \text{ (mol)}$ [1]

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

(v) $[\text{Fe}^{2+}] = 1.5 \times 10^{-3} \times 1000/2.5 = 0.6 \text{ (mol dm}^{-3}\text{)}$ 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 $\text{Fe}^{3+} = 0.15 - 0.06 = 0.09 \text{ mol}$. ecf from (v) [1]

This can react with 0.045 mol of Cu, which = $0.045 \times 63.5 = 2.86 \text{ g}$ of copper. ecf [1]

[6]

(c) bonds broken are Si-Si and $\text{Cl-Cl} = 222 + 244 = 466 \text{ kJ mol}^{-1}$

bonds formed are $2 \times \text{Si-Cl} = 2 \times 359 = 718 \text{ kJ mol}^{-1}$

$\Delta H = -252 \text{ kJ mol}^{-1}$ [2]

[2]

(d) (i) $\text{Ca}_2\text{Si} + 6\text{H}_2\text{O} \longrightarrow 2\text{Ca(OH)}_2 + \text{SiO}_2 + 4\text{H}_2$ [1]

(ii) silicon has been oxidised **AND** hydrogen has been reduced [1]

[2]

[Total: 14]

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- 2 (a) (i) A = CuSO₄ [1]
 B = silver [1]
- (ii) salt bridge [1]
 voltmeter [1]
- [4]
- (b) (i) $0.80 - 0.34 = (+) 0.46 \text{ V}$ [1]
- (ii) If $E_{\text{cell}} = 0.17$, this is 0.29 V less than the standard E^\ominus ,
 so $E_{\text{Ag electrode}}$ must = $0.80 - 0.29 = 0.51 \text{ V}$ [1]
- (iii) $0.51 = 0.80 + 0.06 \log [\text{Ag}^+]$, so $[\text{Ag}^+] = 10^{(-0.29/0.06)} = \underline{1.47 \times 10^{-5}} \text{ mol dm}^{-3}$ ecf from (ii) [1]
- [3]
- (c) (i) $K_{\text{sp}} = [\text{Ag}^+]^2 [\text{SO}_4^{2-}]$ [1]
 units = $\text{mol}^3 \text{ dm}^{-9}$ ecf on K_{sp} [1]
- (ii) $[\text{SO}_4^{2-}] = [\text{Ag}^+]/2$ $K_{\text{sp}} = (1.6 \times 10^{-2})^2 \times 0.8 \times 10^{-2} = \underline{2.05 \times 10^{-6}} (\text{mol}^3 \text{ dm}^{-9})$ [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. $\text{N}_2 + 3\text{H}_2 \longrightarrow 2\text{NH}_3$ [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 $\text{S}_2\text{O}_8^{2-} + \text{I}^-$) linked to correct system [1]

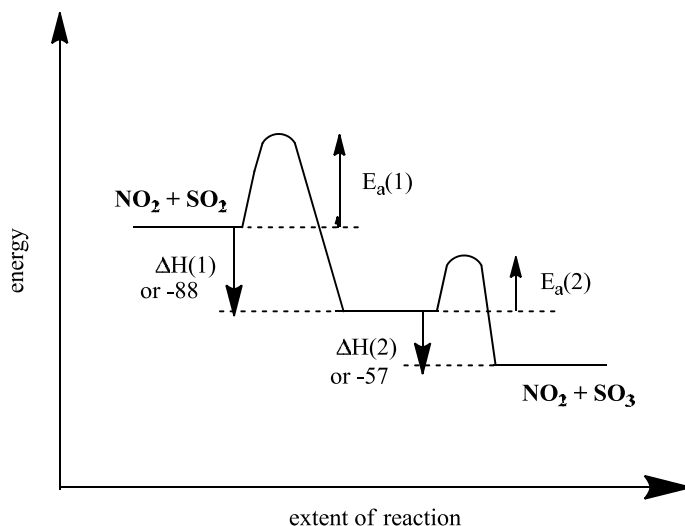
equation, e.g. $\text{S}_2\text{O}_8^{2-} + 2\text{I}^- \longrightarrow 2\text{SO}_4^{2-} + \text{I}_2$ [1]

how catalyst works, e.g. $\text{Fe}^{3+} + \text{I}^- \longrightarrow \text{Fe}^{2+} + \frac{1}{2}\text{I}_2$ [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) $\text{K}_2\text{Cr}_2\text{O}_7 + \text{H}^+ + \text{heat}$ under reflux [1]

(b) nucleophilic substitution [1]

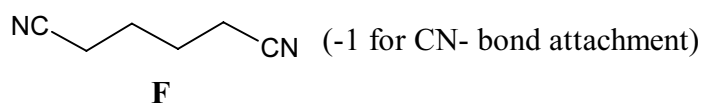
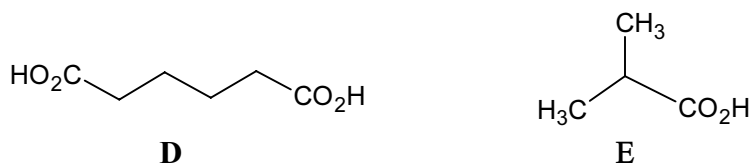
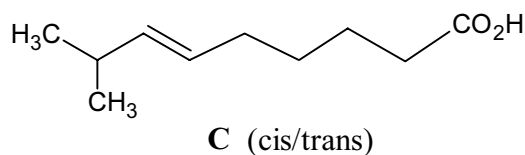
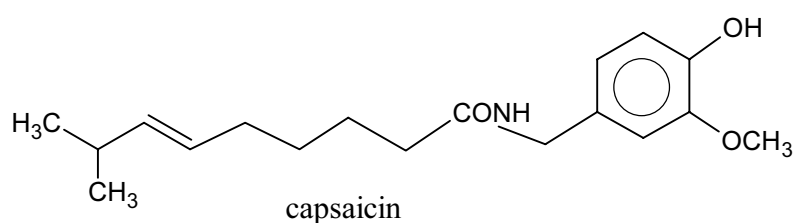
(c) heat under reflux + aqueous HCl [1]

(d) alkene [1]

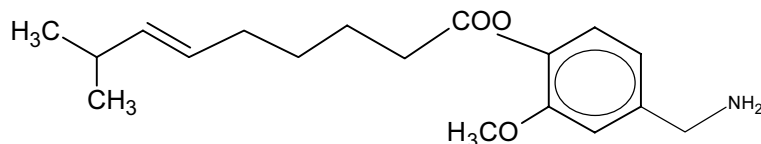
(e) amide or ester [1]

[5]

(f)



alternative structure for capsaicin



ecf 5 × [1]

[5]

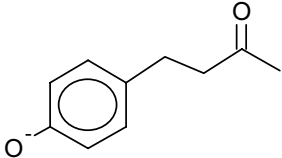
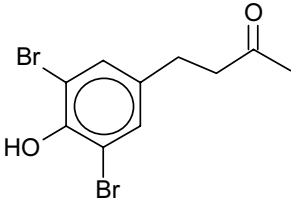
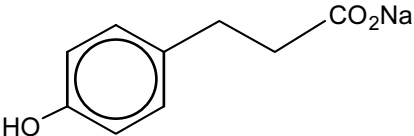
[Total: 10]

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

[2]

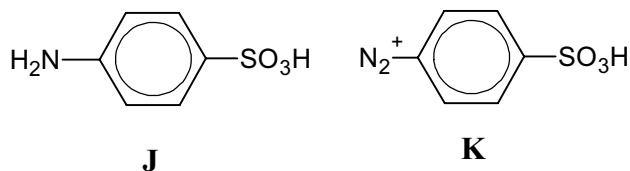
(b)

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

[2]

[8]

(c) (i)



[1] + [1]

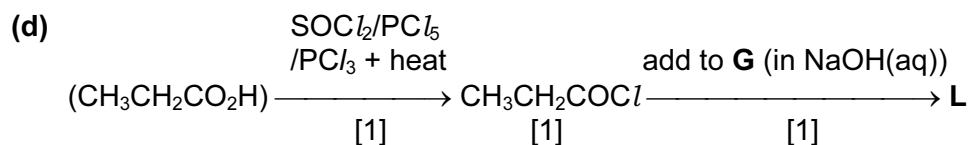
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(ii) step 1: $\text{NaNO}_2 + \text{HCl}$ or HNO_2 [1]

at $T < 10^\circ\text{C}$ [1]

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

[5]



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 \rightarrow [0], two correct only \rightarrow [1], three correct only \rightarrow [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 \times [1]Non-competitive: **any two** from:

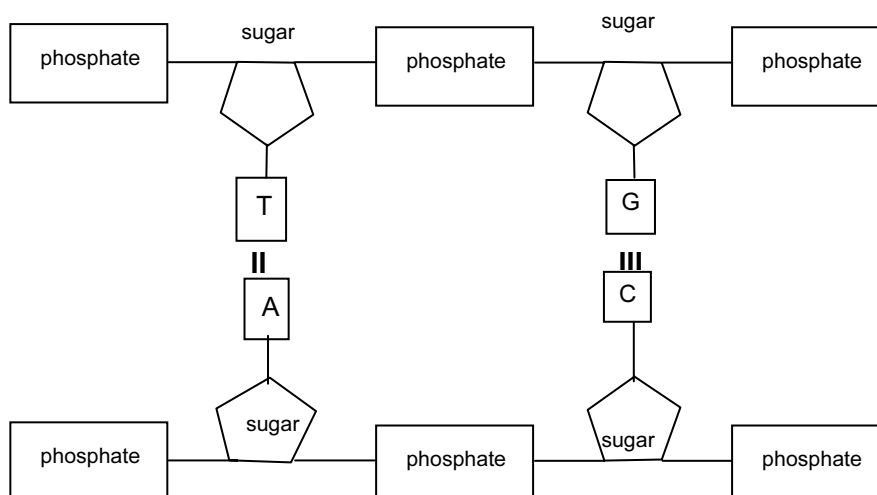
- binds elsewhere in the enzyme than active site / at an allosteric site
- this changes the shape of the active site
- cannot be removed by increasing [substrate]

2 \times [1]

[4]

| | | | |
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(c)



A and C **and** other strand correct

H-bonds labelled

adenine **AND** cytosine

[1]

[1]

[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 $\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}_3$ [1]

any **four** of:

- 3 different (proton) environments
- (M and M+1 data shows no of carbons present is) $(100 \times 0.22)/(1.1 \times 5.1) = 4$ carbons
- the NMR spectrum shows 8 hydrogens leaving 32 mass unit or 2 oxygen **or** $M_r = 88$ **and** (molecular formula is) $\text{C}_4\text{H}_8\text{O}_2$
- 4 peaks/quartet (at 4.1) shows an adjacent $3\text{H}/\text{CH}_3$
- 3 peaks/triplet (at 1.3) shows an adjacent $2\text{H}/\text{CH}_2$
- (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]

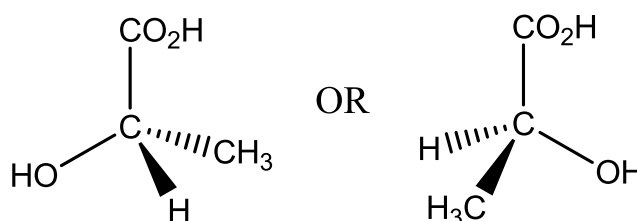
[Total: 10]

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]

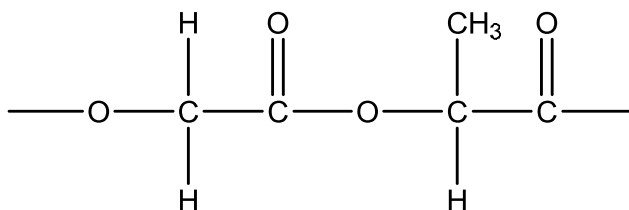
(c) (i) (Acid present would) hydrolyse the ester (linkage) [1]

(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 CH₃/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]