

## 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.

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1 (a)  $\text{SiCl}_4$ : white solid or white/steamy fumes [1]



$\text{PCl}_5$ : 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  $\text{Fe}^{3+}$  in  $100 \text{ cm}^3$ .  
In the partially-used solution, there is 0.06 mol of  $\text{Fe}^{2+}$  in  $100 \text{ cm}^3$ .

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 = CuSO<sub>4</sub> [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  $E^{\circ}$ ,  
 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  $K_{\text{sp}}$  [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.  $\text{Fe}^{3+}$  or  $\text{Fe}^{2+}$  (in  $\text{S}_2\text{O}_8^{2-} + \text{I}^-$ ) linked to correct system [1]

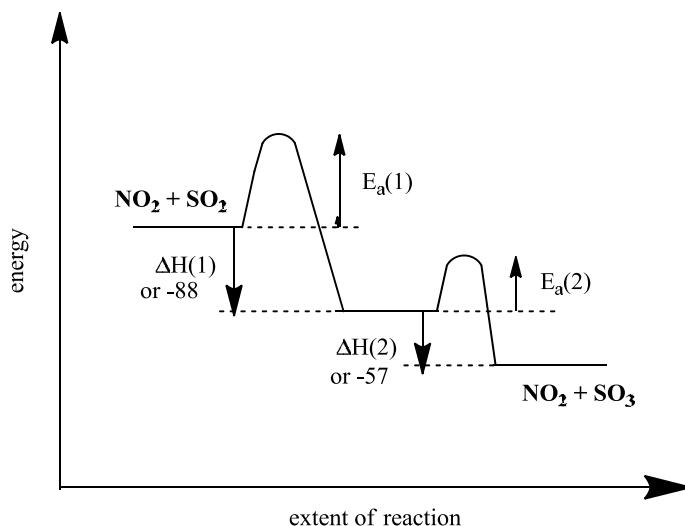
equation, e.g.  $\text{S}_2\text{O}_8^{2-} + 2\text{I}^- \longrightarrow 2\text{SO}_4^{2-} + \text{I}_2$  [1]

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  $\Delta H$  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]

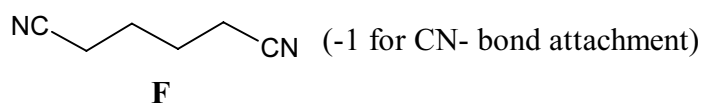
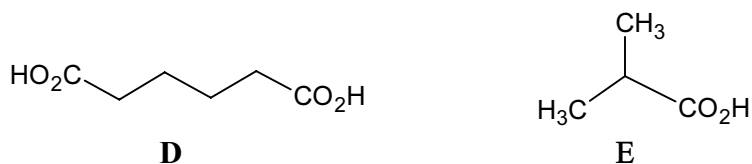
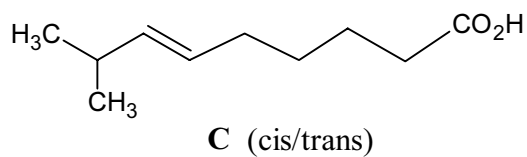
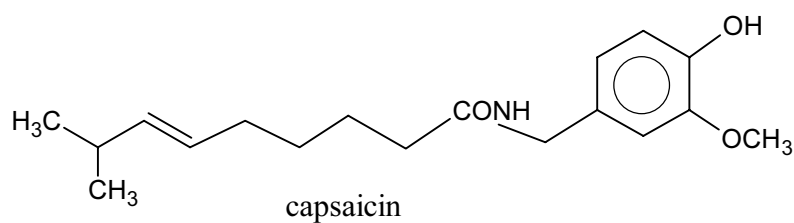
(c) heat under reflux + aqueous  $\text{HCl}$  [1]

(d) alkene [1]

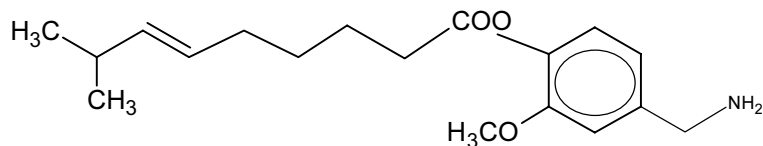
(e) amide or ester [1]

[5]

(f)



alternative structure for capsaicin



ecf 5 × [1]

[5]

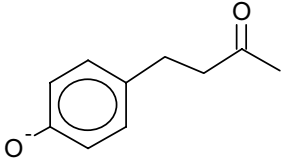
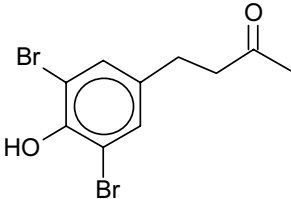
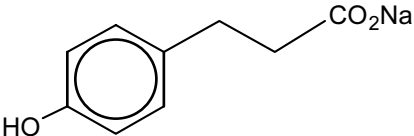
[Total: 10]

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

[2]

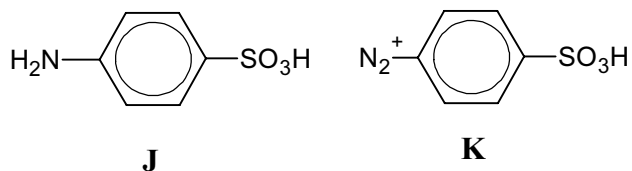
(b)

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

[2]

[8]

(c) (i)



[1] + [1]

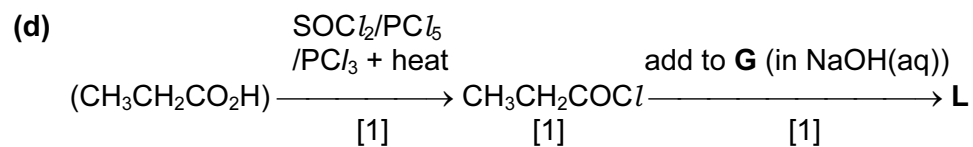
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(ii) step 1:  $\text{NaNO}_2 + \text{HCl}$  or  $\text{HNO}_2$  [1]

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

step 2: (add **K** to a solution of **G**) in aqueous  $\text{NaOH}$  [1]

[5]



ecf from  $\text{CH}_3\text{COOH}$  [3]

[Total: 18]

### Section B

6 (a)

bonding	structure involved
disulfide bonds between parts of the chain	tertiary
hydrogen bonds in a $\beta$ -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]

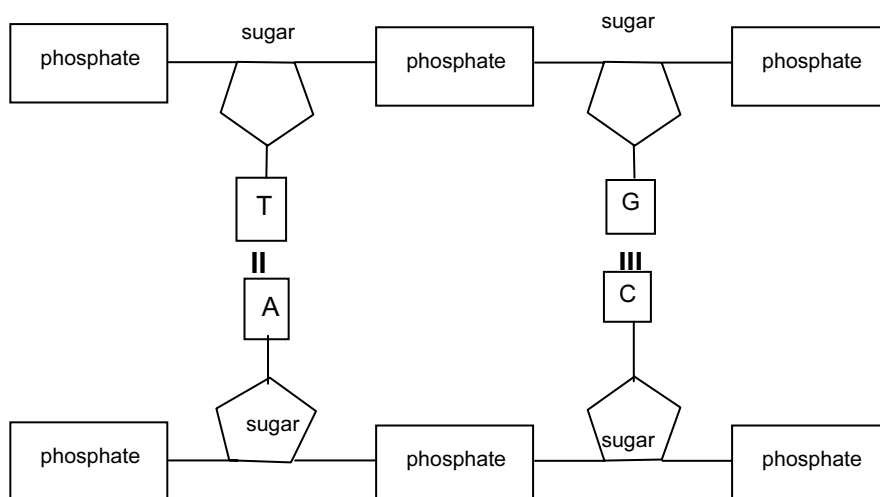
2 × [1]

[4]



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(c)



A and C **and** other strand correct

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  $\text{CH}_3\text{CO}$  (group)
- (peak at) 4.1/quartet **and** 1.3/triplet shows presence of ethyl/ $\text{CH}_3\text{CH}_2$  (group)

4 × [1]

[5]

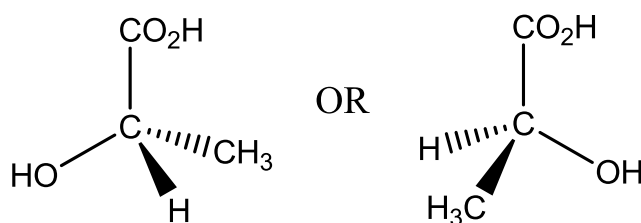
[Total: 10]

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]

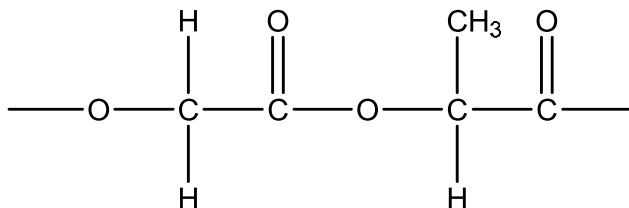
(c) (i) (Acid present would) hydrolyse the ester (linkage) [1]

(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<sub>3</sub>/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]