

**UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS**

**GCE Advanced Subsidiary Level and GCE Advanced Level**

**MARK SCHEME for the October/November 2009 question paper  
for the guidance of teachers**

**9701/42**

**9701 CHEMISTRY**

Paper 42 (A2 Structured Questions),  
maximum raw mark 100

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- 1 (a) Sulfates become **less soluble** down the group [1]  
 both lattice energy and hydration (are involved) [1]  
 but hydration energy decreases more than lattice energy  
 or HE becomes less than LE or HE decreases whereas LE is almost constant [1]  
 (due to cationic radius increasing) [3]
- (b) (i)  $n(\text{CO}) = pV/RT = 1.01 \times 10^5 \times 140 \times 10^{-3} / (8.31 \times 450) = \mathbf{3.78}$   
 or  $= 140 \times (273/450) / 22.4 = \mathbf{3.79}$   
 allow =  $140 \times (298/450) / 24.0 = 3.86$  [1]
- (ii)  $n(\text{BaSO}_4) = n(\text{CO})/4 = \mathbf{0.945}$  moles (or 0.9475) [1]  
 If RTP used answer is **0.966**
- (iii)  $M_r = 233$ , [1]  
 so  $0.945 \text{ mol} = 0.945 \times 233 = 220\text{g} \Rightarrow 100 \times 220/250 = \mathbf{88(.07)\%}$  [1]  
 (or  $0.9475 \text{ mol} \Rightarrow 220.8\text{g} \Rightarrow 88(.3)\%$ )  
 If RTP used answer is **90(.0)%** [4]
- (c) (i) from data booklet, 1<sup>st</sup> IE = 502; 2<sup>nd</sup> IE = 966; sum = 1468 kJ mol<sup>-1</sup>  
 so  $-460 = 1468 + 180 + 279 - 200 + 640 + \text{LE}$   
 $-460 = 2367 + \text{LE}$   
 $\text{LE} = \mathbf{-2827 \text{ kJ mol}^{-1}}$   
 (-1 for each error) [3]
- (ii) LE of BaS should be smaller than that of BaO, since S<sup>2-</sup> is bigger than O<sup>2-</sup>. [1]  
 [4]

[Total: 11]

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2 (a) ethylamine > NH<sub>3</sub>, but phenylamine < NH<sub>3</sub> [1]

in ethylamine, the alkyl group donates electrons to the N, making lone pair more available [1]

in phenylamine, the lone pair is delocalised over the ring, so is less available [1]

[3]

(b)

halide	observation when AgNO <sub>3</sub> (aq) is added	observation when dilute NH <sub>3</sub> (aq) is added	observation when concentrated NH <sub>3</sub> (aq) is added
chloride	<b>white ppt</b>	<b>dissolves</b>	<b>dissolves</b>
bromide	<b>cream ppt</b>	<b>no reaction / slightly dissolves</b>	<b>dissolves</b>
iodide	<b>(pale) yellow ppt</b>	<b>no reaction</b>	<b>no reaction</b>

[1]

[1]

[1]

[3]

(c) (i)  $[Ag^+(aq)] = \sqrt{K_{sp}} = \sqrt{(5 \times 10^{-13})} = 7.1 (7.07) \times 10^{-7} \text{ mol dm}^{-3}$  [1]

(ii) AgBr will be **less soluble** in KBr, due to common ion effect *or* equilibrium is shifted to the left / or by Le Chatelier's principle [1]

[2]

(d) (i)  $K_c = \frac{[Ag(RNH_2)_2^+]}{[Ag^+][RNH_2]^2}$  [1]  
units are mol<sup>-2</sup> dm<sup>6</sup> [1]

(ii) assume that most of the Ag<sup>+</sup>(aq) has gone to the complex, then

$$[Ag^+(aq)] = 7.1 \times 10^{-7}$$

$$[Ag(NH_3)_2^+] = 0.1$$

$$\text{and } [NH_3] = \sqrt{\frac{[Ag(NH_3)_2^+]}{K_c[Ag^+]}} = \sqrt{\frac{0.1}{(1.7 \times 10^7 \times 7.1 \times 10^{-7})}} \quad [1]$$

$$= 0.091 \text{ mol dm}^{-3} \quad [1]$$

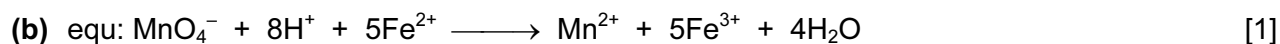
(iii) When R = C<sub>2</sub>H<sub>5</sub>, K<sub>c</sub> is likely to be greater, since the ethyl group will cause the lone pair on N to be more available / nucleophilic / increases basicity [1]

[5]

[Total: 13]

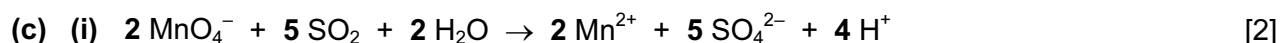
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- 3 (a) Any two from: high(-ish) density of metal  
variable oxidation states  
ability to form complexes  
formation of coloured compounds  
incomplete d subshell  
high m.p. / b.p. [1] + [1]  
**[2]**

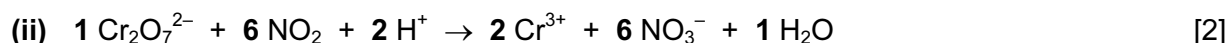


method: Take a known volume of  $\text{Fe}^{2+}(\text{aq})$  in a pipette and place in (conical) flask  
Add an excess of (dil)  $\text{H}_2\text{SO}_4$   
Titrate until end point is reached and note volume used  
End point is first permanent pink colour  
Repeat titration & take average of consistent readings

any 3 points [3]  
**[4]**



oxidation numbers:      **+7**      **+4**                      **+2**      **+6** [1]



oxidation numbers:      **+6**      **+4**                      **+3**      **+5** [1]

([2] marks for each equation: [1] for balancing of redox species,  
[1] for total balancing: i.e.  $\text{H}_2\text{O}$  and  $\text{H}^+$ )

**[6]**

- (d)  $\text{Fe}^{3+}$  is a homogeneous (catalyst)  
 $\text{Fe}^{3+}$  oxidised  $\text{I}^-$  (and is reduced to  $\text{Fe}^{2+}$ )  
 $\text{Fe}^{2+}$  reduces  $\text{S}_2\text{O}_8^{2-}$  (and is oxidised to  $\text{Fe}^{3+}$ )  
or equations showing this

any two points [2]  
**[2]**

**[Total: 14]**

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- 4 (a) The energy required to break.... [1]  
.....1 mole of bonds in the gas phase [1]  
[2]
- (b) HCl: nothing happens AND HI: purple fumes (at a low temperature) [1]  
purple is **iodine** formed (or in an equation:  $2\text{HI} \longrightarrow \text{H}_2 + \text{I}_2$ ) [1]  
H-X bond energy becomes smaller/weaker down the group [1]  
[3]
- (c) data needed: F-F = 158  
Cl-Cl = 244  
 $6 E(\text{Cl-F}) - 328 = 3 \times 158 + 244$   
 $E(\text{Cl-F}) = +174 \text{ (kJ mol}^{-1}\text{)}$  [2]  
[2]

[Total: 7]

5 (a)

compound	all carbon atoms can be coplanar	not all carbon atoms coplanar
<b>A</b>	✓	
<b>B</b>		✓
<b>C</b>	✓	
<b>D</b>	✓	
<b>E</b>	✓	

all 5 correct [3]  
(4 correct: [2], 3 correct: [1], <3 correct: [0])  
[3]

- (b) reaction I:  $\text{Cl}_2 + \text{AlCl}_3 / \text{FeCl}_3 / \text{Fe} /$  or bromides of Al or Fe [1]  
reaction II:  $\text{Cl}_2 + \text{heat} / \text{light} / \text{uv} / \text{hf}$  [1]  
[2]
- (c) (i) H is  $\text{C}_6\text{H}_5\text{CH}_2\text{Cl}$  [1]
- (ii) reaction III:  $\text{KMnO}_4 + \text{heat} (+ \text{OH}^-)$  [1]  
reaction V:  $\text{NaOH}$  in water + heat [1]  
reaction VI: conc  $\text{H}_2\text{SO}_4 + \text{heat}$  [1]
- (iii) reaction III: oxidation [1]  
reaction V: hydrolysis or nucleophilic substitution [1]  
[6]

[Total: 11]

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- 6 (a) L is  $\text{CH}_3\text{CH}_2\text{Br}$   
M is  $\text{CH}_3\text{CO}_2\text{H}$   
N is  $\text{CH}_3\text{CH}_2\text{NH}_2$   
Q is  $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$   
P is  $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$   
J is  $\text{CH}_3\text{CH}_2\text{CONHCH}_2\text{CH}_3$   
K is  $\text{CH}_3\text{CONHCH}_2\text{CH}_2\text{CH}_3$  [7]  
[7]
- (b) reaction I: KCN, heat NOT  $\text{H}^+$  OR HCN aq negates [1]  
reaction II:  $\text{SOCl}_2$  or  $\text{PCl}_5$  or  $\text{PCl}_3$  BUT aq negates [1]  
reaction IV:  $\text{H}_2 + \text{Ni}$  or  $\text{LiAlH}_4$  or  $\text{NaBH}_4$  NOT Sn + HCl [1]  
[3]
- (c) reaction IV: reduction [1]  
reaction VI: nucleophilic substitution or condensation reaction [1]  
[2]
- (d) (i) amide [1]  
(ii) amine [1]  
[2]
- [Total: 14]
- 7 (a) Primary: Covalent bond (ignore amide, peptide etc.) [1]  
Diagram showing peptide bond:  $(-\text{CHR}-)\text{CONH}(-\text{CHR}-)$  [1]
- Secondary: Hydrogen bonds (NOT between side chains) [1]  
Diagram showing  $\text{N}-\text{H}\cdots\text{O}=\text{C}$  [1]
- Tertiary: **Two** of the following:  
  - hydrogen bonds (diagram **must** show H-bonds *other* than those in  $\alpha$ -helix or  $\beta$ -pleated sheet – e.g. ser-ser)
  - electrostatic/ionic attraction,
  - Van der Waals'/hydrophobic forces/bonds,
  - (covalent) disulphide (links/bridges) [1] + [1]
Suitable diagram of **one** of the above [1]  
(for disulphide: S-S **not** S=S or SH-SH)
- [max 6]
- (b) Substrate binds to the active site of the enzyme [1]  
Interaction with site causes a specific bond to be weakened, (which breaks)  
Or change in shape weakens bond(s) / lowers activation energy [1]  
[2]
- (c) Non-competitive inhibition [1]  
Rate never reaches  $V_{max}$  [1]  
[2]
- [Total: 10]

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8 (a) Ratio of the concentrations of a solute / distribution of solute [1] in two immiscible liquids [1]  
[2]

(b)  $K_c = \frac{[\text{pesticide in hexane}]}{[\text{pesticide in water}]}$  hence  $8.0 = \frac{[\text{pesticide in hexane}]}{0.0050 - [\text{pesticide in hexane}]}$  [1]

Therefore  $[\text{pesticide in hexane}] = x = 0.040 - 8x$

Hence  $x = 0.0044(\text{g})$  [1]  
[2]

(c) (i) Ratio would be 3 : 1 [1]

(ii) Each chlorine atom could be  $^{35}\text{Cl}$  or  $^{37}\text{Cl}$   
Only way of getting M+4 is for both chlorines to be  $^{37}\text{Cl}$  (1 in 9 chance) [1]

Ratio of peaks M M+2 M+4  
9 6 1 [1]

[3]

(d) (i) Accept dioxins and furans (without specifying) [1]

(ii) PCBs (but don't penalise non-specified dioxins and furans) [1]

(iii) Allow : pollution control / environmental legislation / removal of dioxins and furans / mill closed down (owtte) [1]

(iv) Five [1]  
[4]

[Total: 11]

