

**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

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) 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  $0.9475 \text{ mol} \Rightarrow 220.8\text{g} \Rightarrow 88(.3)\%$ ) [1]  
 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

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

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

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

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

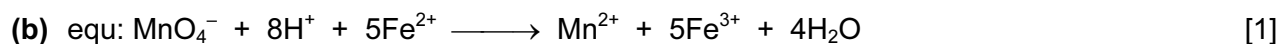
(iii) When R = C<sub>2</sub>H<sub>5</sub>, K<sub>c</sub> is likely to be greater, since the ethyl group will cause the lone pair on N to be more available / nucleophilic / increases basicity [1]

[5]

[Total: 13]

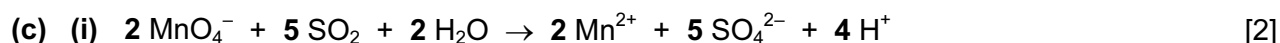
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- 3 (a) Any two from: high(-ish) density of metal  
 variable oxidation states  
 ability to form complexes  
 formation of coloured compounds  
 incomplete d subshell  
 high m.p. / b.p. [1] + [1]  
 [2]

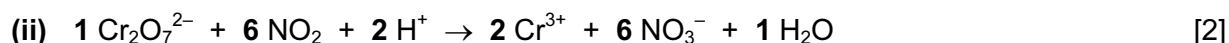


method: Take a known volume of  $\text{Fe}^{2+}(\text{aq})$  in a pipette and place in (conical) flask  
 Add an excess of (dil)  $\text{H}_2\text{SO}_4$   
 Titrate until end point is reached and note volume used  
 End point is first permanent pink colour  
 Repeat titration & take average of consistent 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  $[\text{pesticide in hexane}] = 0.040 - 8x$   
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]

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- 9 (a) Length of DNA        nanosphere diameter        cell diameter  
                           3    1    2

Both marks for correct sequence, [1] for cell smaller than DNA

[2]

(b) (i) Gaps in structure of shaft much smaller, hence less prone to fracture / more flexible [1]

(ii) Composites and carbon nanotubes less dense than metal (of comparable strength) [1]  
 [2]

(c) Wavelength of infrared energy is longer than that of light [1]  
 Gaps between nano-sized particles allow light to pass through, but reflect infrared energy [1]  
 [2]

(d) (i) Resistance to corrosion / reaction [1]

(ii) Ability to kill bacteria / prevent bacteria multiplying [1]

(iii) Very much larger surface area means they dissolve more readily [1]  
 [3]

[Total: 9]