

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 $0.9475 \text{ mol} \Rightarrow 220.8\text{g} \Rightarrow 88(.3)\%$) [1]
 If RTP used answer is **90(.0)%** [4]
- (c) (i) from data booklet, 1st IE = 502; 2nd IE = 966; sum = 1468 kJ mol⁻¹
 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 S²⁻ is bigger than O²⁻. [1]
 [4]

[Total: 11]

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2 (a) ethylamine > NH₃, but phenylamine < NH₃ [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 ₃ (aq) is added	observation when dilute NH ₃ (aq) is added	observation when concentrated NH ₃ (aq) is added
chloride	white ppt	dissolves	dissolves
bromide	cream ppt	no reaction / slightly dissolves	dissolves
iodide	(pale) yellow ppt	no reaction	no reaction

[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⁻² dm⁶ [1]

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

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

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

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

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

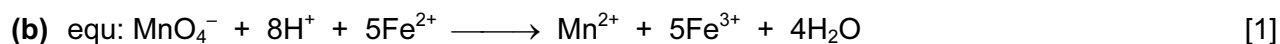
(iii) When R = C₂H₅, K_c is likely to be greater, since the ethyl group will cause the lone pair on N to be more available / nucleophilic / increases basicity [1]

[5]

[Total: 13]

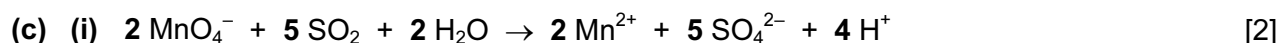
Page 4	Mark Scheme: Teachers' version	Syllabus	Paper
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- 3 (a) Any two from: high(-ish) density of metal
variable oxidation states
ability to form complexes
formation of coloured compounds
incomplete d subshell
high m.p. / b.p. [1] + [1]
[2]

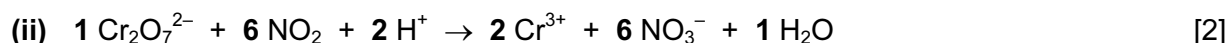


method: Take a known volume of $\text{Fe}^{2+}(\text{aq})$ in a pipette and place in (conical) flask
Add an excess of (dil) H_2SO_4
Titrate until end point is reached and note volume used
End point is first permanent pink colour
Repeat titration & take average of consistent readings

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. H_2O and H^+)

[6]

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

any two points [2]
[2]

[Total: 14]

Page 5	Mark Scheme: Teachers' version	Syllabus	Paper
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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
A	✓	
B		✓
C	✓	
D	✓	
E	✓	

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: 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]

Page 6	Mark Scheme: Teachers' version	Syllabus	Paper
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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 H^+ OR HCN aq negates [1]
reaction II: SOCl_2 or PCl_5 or PCl_3 BUT aq negates [1]
reaction IV: $\text{H}_2 + \text{Ni}$ or LiAlH_4 or 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 α -helix or β -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) [1]
Or change in shape weakens bond(s) / lowers activation energy [2]
[2]
- (c) Non-competitive inhibition [1]
Rate never reaches V_{max} [1]
[2]
- [Total: 10]

Page 7	Mark Scheme: Teachers' version	Syllabus	Paper
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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}Cl or ^{37}Cl

Only way of getting M+4 is for both chlorines to be ^{37}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]

