

MARK SCHEME for the October/November 2007 question paper

9701 CHEMISTRY

9701/04

Paper 4 (Theory 2), maximum raw mark 100

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Page 2	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – October/November 2007	9701	04

- 1 (a) (i) $K_a = \frac{[H^+][RCO_2^-]}{[RCO_2H]}$ [1]
- (ii) $pK_a = -\log_{10}K_a$ or $-\log K_a$ or $\log \frac{[H^+]^2}{[RCO_2H]}$ NOT \ln ; [1]
[2]
- (b) (i) acid strength increases from no. 1 to no. 3 or down the table or as Cls increase due to the electron-withdrawing effect/electronegativity of chlorine (atoms) stabilising the anion or weakening the O-H bond NOT H^+ more available [1]
[1]
[1]
- (ii) chlorine atom is further away (from O-H) in no. 4, so has less influence [1]
- (iii) either: $pH = \frac{1}{2}(pK_a - \log_{10}[\text{acid}])$ or $K_a = 10^{-pK_a} = 1.259 \times 10^{-3}$
 $= \frac{1}{2}(4.9 + 2)$ $[H^+] = \sqrt{K_a \cdot c} = 3.55 \times 10^{-4}$ [1]
 $= 3.4$ (allow 3.5) $pH = 3.4$ ecf [1]
 ([1] for correct expression & values; [1] for correct working) [6]
- (c) (i) catalyst [1]
- (ii) $CH_3CH_2CO_2H + Cl_2 \longrightarrow CH_2CHClCO_2H + HCl$ [1]
- (iii) nucleophilic substitution NOT addition/elimination [1]
- (iv) $M_r(CH_3CH_2CO_2H) = 74$ $M_r(CH_2CH(NH_2)CO_2H) = 89$ [1]
 $\therefore 10.0 \text{ g should give } 10 \times 89/74 = 12.03 \text{ g}$
 $\therefore \text{percentage yield} = 100 \times 9.5/12.03 = 79\%$ ecf [1]
 ([2] for correct answer) [5]
- (d) $^+NH_3-CH(CH_3)-CO_2^-$ correct atoms [1]
 Allow charges on H of H_3N , and $-COO$ but not $-C-O-O$ correct charges [1]
 [2]

[Total: 15]

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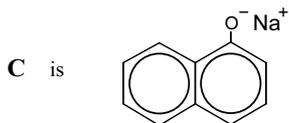
- 2 (a) solubility **decreases** (down Group II) [1]
lattice energy decreases [1]
solvation/hydration energy (of cation) decreases [1]
but more so than does lattice energy/is not able to overcome LE [1]
 ΔH_{soln} becomes more endothermic/positive/less exothermic [1]
[max 4]
- (b) identities of **A** and **B** 2 x [1]
 $\text{Mg(OH)}_2 + \text{H}_2\text{C}_2\text{O}_4 \longrightarrow \text{MgC}_2\text{O}_4(\text{aq}) + 2\text{H}_2\text{O}$ [1]
(A)
- $\text{MgC}_2\text{O}_4(\text{aq}) + \text{Ca(NO}_3)_2 \longrightarrow \text{Mg(NO}_3)_2 + \text{CaC}_2\text{O}_4(\text{s})$ [1]
(B)
[max 3]
- (c) (i) ($K_{\text{sp}} =$) $[\text{Mg}^{2+}][\text{OH}^-]^2$ [1]
units are $\text{mol}^3\text{dm}^{-9}$ ecf from K_{sp} [1]
- (ii) (call $[\text{Mg(OH)}_2(\text{aq})] = [\text{Mg}^{2+}] = x$) $\therefore K_{\text{sp}} = 2 \times 10^{-11} = 4x^3$ [1]
 $\therefore x = 1.71 \times 10^{-4} \text{ mol dm}^{-3}$ ecf [1]
- (iii) less soluble because of the common ion effect [1]
or the equilibrium $\text{Mg(OH)}_2(\text{s}) \rightleftharpoons \text{Mg}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq})$ is moved to the left [1]
[5]
[Total: 12]

Page 5	Mark Scheme	Syllabus	Paper
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- 4 (a) CCl_4 is unreactive. (The rest react (with increasing vigour)) [1]
 no d-orbitals *or* available/low-lying empty orbitals in carbon *or* unable to expand octet [1]
 e.g. $\text{SiCl}_4 + 2\text{H}_2\text{O} \longrightarrow \text{SiO}_2 + 4\text{HCl}$
 (or GeCl_4 etc) *or* $\text{Si(OH)}_2\text{Cl}_2$
or Si(OH)_4
 (allow balanced equations for partial hydrolysis) [1]
[3]
- (b) (i) $E(\text{C}-\text{Cl}) = 244 \text{ kJ mol}^{-1}$; $2 E(\text{C}-\text{Cl}) = 2 \times 340 = 680 \text{ kJ mol}^{-1}$
 $\therefore \Delta H = -436 \text{ (kJ mol}^{-1}\text{)}$ [1]
- (ii) $\Delta H = 359 - 329 = +30 \text{ (kJ mol}^{-1}\text{)}$ [1]
- (iii) since reaction (ii) is endothermic, the +4 oxidation state is less stable
or the +2 oxidation state is more stable (down the group) [1]
[3]
[Total: 6]
- 5 (a) $2 \text{MnO}_4^- + 5 \text{H}_2\text{O}_2 + 6 \text{H}^+ \longrightarrow 2 \text{Mn}^{2+} + 8 \text{H}_2\text{O} + 5 \text{O}_2$ [1]
[1]
- (b) $E_{\text{cell}}^\ominus = 1.52 - 0.68 = +0.84 \text{ (V)}$ [1]
[1]
- (c) (i) (as KMnO_4 is added), colour changed (from purple) to colourless – *NOT* pink [1]
or effervescence/bubbles (of O_2) are produced [1]
 at end-point, change is to (first) pink [1]
- (ii) $n(\text{MnO}_4^-) = 0.02 \times 15/1000 = 3 \times 10^{-4}$ [1]
 since $\text{H}_2\text{O}_2 : \text{MnO}_4^- = 5:2$,
 $\Rightarrow n(\text{H}_2\text{O}_2) = (5/2) \times 3 \times 10^{-4} = 7.5 \times 10^{-4} \text{ in } 25 \text{ cm}^3$
 $\therefore [\text{H}_2\text{O}_2] = 7.5 \times 10^{-4} \times 1000/25 = 3.0 \times 10^{-2} \text{ mol dm}^{-3}$ [1]
[4]
[Total: 6]

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6 (a) (i)



allow ONa but no covalent O-Na bond

[1]

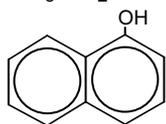
(ii) amide, ester

2 x [1]

(iii) CO_2 or H_2CO_3 or Na_2CO_3
 CH_3NH_2 or $\text{CH}_3\text{NH}_3^+\text{Cl}^-$

[1]

[1]



[1]

(iv) H_3O^+ and heat $>80^\circ$ or $\text{OH}^-(\text{aq})$ and heat $>80^\circ$

[1]

[7]

(b) (i) $\text{Br}_2(\text{aq})$ (or other suitable solvent)

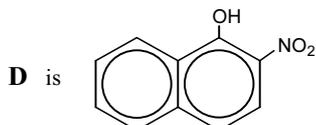
[1]

(ii) dilute/aqueous HNO_3

[1]

[2]

(c) (i)

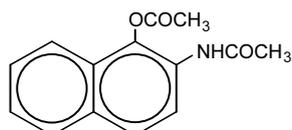


[1]

(ii) tin/Fe + HCl NOT LiAlH_4

[1]

(iii)

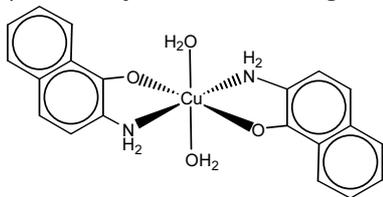


mark each side chain separately

2 x [1]

[4]

(d) (i) (allow any orientation of groups)



penalise missing H on NH_2

[1]

(ii) $[\text{Cu}(\text{NH}_3)_4]^{2+}$ or $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$ NOT $[\text{Cu}(\text{NH}_3)_6]^{2+}$

[1]

(iii) ligand substitution/exchange

[1]

[3]

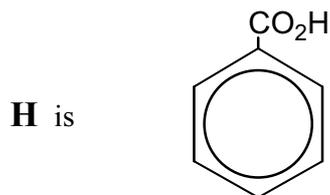
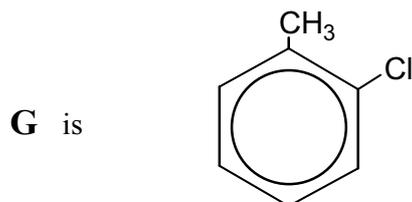
[Total: max 15]

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- 7 (a) $\text{HNO}_3 + \text{H}_2\text{SO}_4$ [1]
 at $50 - 60^\circ\text{C}$ (or $\leq 60^\circ\text{C}$) not dilute or (aq) [1]
 [2]

- (b) $2\text{H}_2\text{SO}_4 + \text{HNO}_3 \longrightarrow 2\text{HSO}_4^- + \text{H}_3\text{O}^+ + \text{NO}_2^+$ [1]
 (allow equ. with only one H_2SO_4 , giving H_2O) [1]

(c)



[1] + [1]

- reaction I: $\text{Cl}_2 + \text{AlCl}_3$ /accept other halogen carriers *NOT* aq, *nor* u.v.
 reaction II: $\text{KMnO}_4 + \text{H}^+$ *NOT* HCl *nor* HNO_3
 reaction III: $\text{KMnO}_4 + \text{H}^+$ *NOT* HCl *nor* HNO_3
 reaction IV: $\text{Cl}_2 + \text{AlCl}_3$ /accept other halogen carriers *NOT* aq, *nor* u.v.

both I + IV [1]
both II + III [1]
 [4]

[Total: 7]

Page 8	Mark Scheme	Syllabus	Paper
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- 8 (a) (i) Two interlinked spirals *or* chains *or* strands woven round each other [1]
(ii) By hydrogen bonds between bases [1]
[2]
- (b) Transcription – (1)DNA/RNA/nucleic acid unravels [1]
– (2)strand is used as a template [1]
– (3)mRNA reads the sequence on this strand/
produces complementary strand [1]
- Translation – (4)mRNA binds to the ribosome [1]
– (5)tRNA translates the codon from mRNA [1]
– (6)tRNA carries amino acids to ribosome/adds a.a. to chain [1]
[**max 4**]
- (c) (i) Disruption of the secondary/tertiary/quaternary/3D structure of the protein
(could be answered in terms of bonds e.g. hydrogen bonds break) [1]
- (ii) The covalent/peptide bonds in the (protein) chain are too strong [1]
[2]
- (d) Energy is provided by the breakdown/hydrolysis of adenosine triphosphate (ATP) [1]
ATP (+ H₂O) → ADP + P_i (+ energy) or in words [1]
ATP is produced during respiration/Krebs cycle/oxidation of glucose, fats or proteins/
in mitochondria/ADP is recycled [1]
[3]
- [**Total: 11**]

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- 9 (a) Suitable diagram showing origin of two energy states/or description [1]
Needs to mention applied magnetic field/electron transfer negates [1]
Indication that energy difference is in the radio frequency range [1]
Indication that frequency of absorption *or* gap between the 2 energy states depends on the nature of nearby atoms *or* the chemical environment of the ¹H [1]
[3]
- (b) They do not damage tissues/X-rays harmful/NMR of lower energy [1]
They are not obscured by bones/skeleton [1]
They can be tuned to examine particular tissues/tumours/*organs*/protons [1]
[max 2]
- (c) (i) $M : M+1 = 100/(1.1n)$

$$n = \frac{0.66 \times 200}{14.5 \times 1.1} = \frac{66}{15.95} = 4.14 = 4 \text{ carbon atoms}$$
 [1]
Check for 1.1 in divisor, if missing, penalise
- (ii) Singlet at δ 2 suggests methyl adjacent to C=O [1]
Quartet at δ 4 suggests a –CH₂- group (adjacent to a –methyl group) [1]
(allow –OCH₂-)
Triplet at δ 1.2 suggests a methyl group (adjacent to a –CH₂-) [1]
G is ethyl ethanoate (or structure)/if methyl propanoate given here cannot score first marking point [1]
[5]
- [Total: 10]**

Page 10	Mark Scheme	Syllabus	Paper
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- 10 (a)** Iron is higher in the reactivity series than copper (owtte)/allow use of E^\ominus [1]
- $\text{Cu}^{2+}(\text{aq}) + \text{Fe}(\text{s}) \rightarrow \text{Cu}(\text{s}) + \text{Fe}^{2+}(\text{aq})$ [1]
 If conversion to Fe^{3+} given, E_{cell} is -0.38 [2]
- (b)** It does not require investment in machinery/labour [1]
- It requires little energy [1]
- accept it produces little/no pollution/noise [1]
 Do not accept comparison with electrolytic method [max 2]
- (c)** The process takes a long time/requires smaller workforce [1]
 [1]
- (d) (i)** 0.75% is 7.5 kg in every tonne of ore
- Hence 150,000 tonnes of ore yield $\frac{7.5 \times 150000}{1000}$ tonnes
 or 1,125 tonnes Cu
- $1125 \times 0.6 = 675$ tonnes (accept 680) [1]
- (ii)** $450 \times 0.17 = 76.5$ tonnes (accept 77) [1]
 or $1125 \times 0.17 = 191.25$ tonnes (accept 191) – this is an ecf if 675 not in (i) [2]
- (e)** Aluminium is too high in the reactivity series/very reactive/aluminium forms bonds with oxygen which are too strong/aluminium ore doesn't exist as sulphide /Fe unable to displace Al [1]
 [1]
- (f)** Control the pH (*greater* than pH 6.0) [1]
 Bioremediation/growth of special plants (to remove heavy metals)
 Other reasonable suggestions such as displacement by a more reactive metal/
 precipitation/ion exchange [1]
 [2]
[Total: 9]