UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2012 question paper

for the guidance of teachers

9701 CHEMISTRY

9701/21 Paper 2 (AS Structured Questions), maximum raw mark 60

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.

Mark schemes must be read in conjunction with the question papers and the report on the examination.

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UNIVERSITY of CAMBRIDGE
International Examinations

1 (a)

Na_2O	MgO	Al_2O_3	SiO_2	P_4O_{10}	SO_2	Cl_2O_7
alkaline	basic	amphoteric	acidic	acidic	acidic	acidic

Na_2O is alkaline – allow basic (1)

MgO is basic – allow alkaline (1)

Al_2O_3 is amphoteric (1)

SiO_2, P_4O_{10}, and SO_2 are **all** acidic (1) [4]

(b) any **two** from:
sodium, phosphorus, sulfur and chlorine
two names required (1) [1]

(c) (i) any **three** from:
floats
vigorous/violent reaction occurs
melts/forms a sphere
moves
disappears – allow dissolves
effervescence/gas produced (any 3)

(ii) $Na + H_2O \rightarrow NaOH + \frac{1}{2}H_2$
or
$2Na + 2H_2O \rightarrow 2NaOH + H_2$ (1) [4]

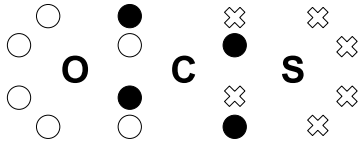
(d) (i) combustion of fossil fuels – e.g. from car engines
from car exhausts **or**
during the extraction of metals from sulfide ores or
volcanic eruptions/burning sulfur from volcanoes or
burning biomass (1)

(ii) H_2SO_4
or
SO_3 allow H_2SO_3 **formula required** (1)

(iii) acid rain
or
its consequences e.g. damage to buildings,
damage to crops, plants, marine life
deforestation
or
SO_3 is toxic (1) [3]

(e) it is a reducing agent/antioxidant
or
it kills bacteria (1) [1]

(f) (i)



(1)

(ii) 180° (1) [2]

[Total: 15]

2 (a) $(NH_4)_2SO_4 + 2NaOH \rightarrow \mathbf{2}NH_3 + \mathbf{Na_2SO_4} + \mathbf{2H_2O}$

correct products (1)

correctly balanced equation (1) [2]

(b) (i) $NaOH + HCl \rightarrow NaCl + H_2O$ (1)

(ii) $n(HCl) = \frac{31.2}{1000} \times 1.00 = 0.0312 = 0.03$ (1)

(iii) $n(NaOH) = \frac{50.0}{1000} \times 2.00 = 0.10$ (1)

(iv) n(NaOH) used up = 0.10 – 0.0312 = 0.0688 = 0.07 (1)

(v) $n[(NH_4)_2SO_4] = \frac{0.0688}{2} = 0.0344 = 0.03$ (1)

(vi) mass of $(NH_4)_2SO_4$ = 0.0344 × 132 = 4.5408 = 4.54 (1)

(vii) percentage purity = $\frac{4.5408 \times 100}{5.00}$ = 90.816 = 90.8 (1) [7]

[Total: 9]

3 **(a)** $C(s) + O_2(g) \rightarrow CO_2(g)$ (1)
the enthalpy change/energy change/heat change when
one mole of a compound/CO_2 (1)
is formed from its elements in their standard states (1) [3]

(b) **(i)**

	$CO_2(g)$	+	$3H_2(g)$	$\rightleftharpoons$	$CH_3OH(g)$	+	$H_2O(g)$
$\Delta H^{\ominus}_f$/kJ mol^{-1}	–394		0		–201		–242

$\Delta H^{\ominus}_{reaction} = -201 + (-242) - (-394)$ (1)
–49 kJ mol^{-1} (1)
correct sign (1)

(ii) removal of CO_2 from the atmosphere (1)
CO_2 is a greenhouse gas/causes global warming (1) [5]

(c) In this part, in each case, the 'effect' must be correctly stated
in order to gain the explanation mark.

higher temperature
yield is reduced/equilibrium goes to LHS (1)
because forward reaction is exothermic/reverse reaction is endothermic (1)

higher pressure
yield is increased **or** equilibrium goes to RHS (1)
fewer moles/molecules on RHS **or** more moles/molecules on LHS (1)

use of catalyst
yield does not change (1)
forward and backward rates speeded up by same amount (1) [6]

[Total: 14]

4 (a) (i) $C_2H_5OH \rightarrow C_2H_4 + H_2O$ (1)

(ii) elimination **or** dehydration (1)

(iii) phosphoric acid **or** concentrated sulfuric acid
sulfuric acid must be 'concentrated'
allow aluminium oxide (1) [3]

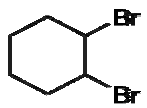
(b)

	with HBr	**with MnO_4^-**
colour at start	colourless	purple **or** pink
colour after reaction	colourless	colourless **or** decolourised
structural formula of product	CH_3CH_2Br	$HOCH_2CH_2OH$

with hydrogen bromide
from colourless **to** colourless **both** colours required
do not allow 'clear' instead of colourless (1)
CH_3CH_2Br (1)
with potassium manganate(VII)
from purple/pink **to** colourless/decolourised **both** colours required (1)
$HOCH_2CH_2OH$ (1) [4]

(c) (i) C_6H_{10} (1)

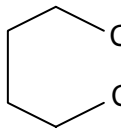
(ii)



accept answers which have $–CH_2–$ in the ring (1)

(iii) electrophilic (1)
addition (1)

(iv)



or

$HO_2C(CH_2)_4CO_2H$ **or**
$HO_2CCH_2CH_2CH_2CH_2CO_2H$ (1)
accept answers which have $–CH_2–$ in the ring [5]

[Total: 12]

5 **(a)** carboxylic acid **or** $–CO_2H$ **or** –COOH (1) [1]

(b) **(i)** alcohol (1)

(ii) $n(H_2) = \frac{160}{24000} = 6.67 \times 10^{-3}$ mol (1)

n(H atoms) = $2 \times 6.67 \times 10^{-3}$ mol = 1.33×10^{-2} mol (1)

(iii) $n(\mathbf{X}) = \frac{0.600}{90} = 6.67 \times 10^{-3}$ mol

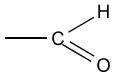
$n(\mathbf{X}) : n$(H atoms) = $6.67 \times 10^{-3} : 1.33 \times 10^{-2}$

= 1 : 2

since each –OH group produces one H atom

there are two –OH groups (1) [4]

(c) **(i)**



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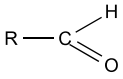

(1)

(ii) $HOCH_2CH(OH)CHO$ as the minimum

allow the *gem* diols $(HO)_2CHCH_2CHO$ **or** $CH_3C(OH)_2CHO$ (1)

(iii) $HOCH_2CH(OH)CO_2H$ or $HOCH_2CH(OH)CO_2^-$ (1) [3]

(d) **(i)** $HOCH_2CH(OH)CH_2OH$ (1)

(ii) HO_2CCOCO_2H (1) [2]

[Total: 10]