

**MARK SCHEME for the October/November 2010 question paper
for the guidance of teachers**

9701 CHEMISTRY

9701/21

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

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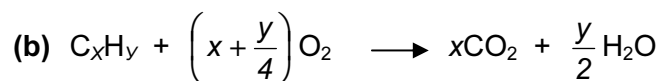
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Page 2	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE A/AS LEVEL – October/November 2010	9701	21

1 (a) the actual number of atoms of each element present (1)

in one molecule of a compound (1)

[2]



$x\text{CO}_2$ (1)

$\frac{y}{2} \text{H}_2\text{O}$ (1)

[2]

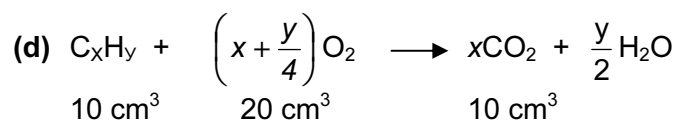
(c) (i) oxygen/ O_2 (1)

(ii) carbon dioxide/ CO_2 (1)

(iii) 10 cm^3 (1)

(iv) 20 cm^3 (1)

[4]



1 mol of C_xH_y gives 1 mol of CO_2

whence $x = 1$ (1)

1 mol of C_xH_y reacts with 2 mol of O_2

whence $\left(x + \frac{y}{4}\right) = 2$

and $y = 4$ (1)

molecular formula is CH_4 (1)

[3]

[Total: 11]

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2 (a) $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$ (1) [1]

(b) temperature between 300 and 550°C (1)

correct explanation of effect of temperature on
rate of formation of NH_3 **or** on position of equilibrium (1)

catalyst of iron **or** iron oxide (1)

to speed up reaction **or** to reduce E_a (1) [4]

(c) manufacture of HNO_3

or explosives

or nylon

or as a cleaning agent

or as a refrigerant (1)

[1]

(d) fertiliser in rivers causes excessive growth of aquatic plants/algae (1)

when plants and algae die O_2 is used up/fish or aquatic life die (1) [2]

(e) (i) CO by incomplete combustion of the hydrocarbon fuel (1)

NO by reaction between N_2 and O_2 in the engine (1)

(ii) CO toxic/effect on haemoglobin (1)

NO toxic/formation of acid rain (1) [4]

(f) (i) platinum/Pt – allow palladium/Pd **or** rhodium/Rh (1)

(ii) $2\text{CO} + 2\text{NO} \rightarrow 2\text{CO}_2 + \text{N}_2$ (1) [2]

[Total: 14]

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3 (a) (i) a compound which contains **only** carbon and hydrogen (1)

(ii) separation of compounds by their boiling points (1) [2]

(b) (i) high temperature **and** high pressure (1)

high temperature **and** catalyst (1)

(ii) $C_{11}H_{24} \rightarrow C_5H_{12} + C_6H_{12}$ **or**

$C_{11}H_{24} \rightarrow C_5H_{12} + 2C_3H_6$ **or**

$C_{11}H_{24} \rightarrow C_5H_{12} + 3C_2H_4$ (1) [3]

(c) (i)

$CH_3CH_2CH_2CH_2CH_3$	$CH_3CH_2CHCH_3$ CH_3	CH_3 CH_3CCH_3 CH_3
isomer B	isomer C	isomer D
(1)	(1)	(1)

(ii) the straight chain isomer (isomer **B** above) (1)

it has the greatest van der Waals' forces (1)

because unbranched molecules have greater area of contact/
can pack more closely together (1)

[6]

(d) enthalpy change when 1 mol of a substance (1)

is burnt in an excess of oxygen/air under standard conditions
or is completely combusted under standard conditions (1)

[2]

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(e) (i) heat released = $m c \delta T = 200 \times 4.18 \times 27.5$ (1)

$$= 22990 \text{ J} = 23.0 \text{ kJ} \text{ (1)}$$

(ii) 23.0 kJ produced from 0.47 g of **E**

$$2059 \text{ kJ produced from } \frac{0.47 \times 2059}{23.0} \text{ g of } \mathbf{E} \text{ (1)}$$

$$= 42.08 \text{ g of } \mathbf{E} \text{ (1)}$$

allow ecf in (i) or (ii) on candidate's expressions [4]

(f) $\text{C}_3\text{H}_6 = 42$

E is C_3H_6

for ecf, **E** must be unsaturated and be no larger than C_5 (1) [1]

[Total: 18]

4	(a) reaction 1	reagent	NaOH/KOH (1)	[6]
		solvent	H_2O /water/aqueous (1)	
	reaction 2	reagent	NH_3 /ammonia (1)	
		solvent	ethanol/ $\text{C}_2\text{H}_5\text{OH}$ /alcohol (1)	
	reaction 3	reagent	NaOH/KOH (1)	
		solvent	ethanol/ $\text{C}_2\text{H}_5\text{OH}$ /alcohol (1)	

(b) with $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{I}$ rate would be faster (1)

C-I bond is weaker than C-Br bond (1)

C-I bond energy is 240 kJ mol^{-1} , C-Br bond energy is 280 kJ mol^{-1}
data **must** be quoted for this mark (1) [3]

(c)	non-toxic	non-flammable	[2]
	volatile/low bp	unreactive (any 2)	

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(d) (i) when a covalent bond breaks the two electrons in the bond are shared between the two atoms (1)

(ii) $\text{CCl}_2\text{F}_2 \rightarrow \text{CClF}_2 + \text{Cl}$ (as minimum)

allow $\text{CCl}_2\text{F} + \text{F}$ (1) [2]

(e) they are flammable (1) [1]

[Total: 14]

5 (a) NaBr/sodium bromide [1]

(b) Br_2 /bromine or SO_2 /sulfur dioxide [1]

(c) concentrated sulfuric acid is an oxidising agent
or
 phosphoric(V) acid is **not** an oxidising agent [1]

[Total: 3]

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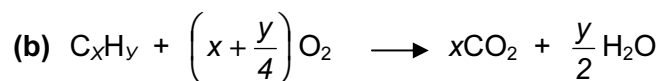
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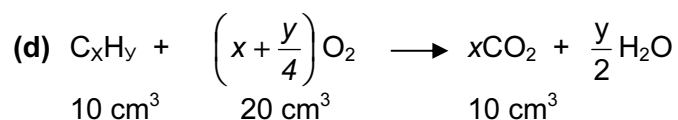
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- solvent H_2O /water/aqueous (1)
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- solvent ethanol/ $\text{C}_2\text{H}_5\text{OH}$ /alcohol (1)
- reaction 3 reagent NaOH/KOH (1)
- solvent ethanol/ $\text{C}_2\text{H}_5\text{OH}$ /alcohol (1)

[6]

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5 (a) NaBr/sodium bromide [1]

(b) Br_2 /bromine or SO_2 /sulfur dioxide [1]

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- 1 (a) atoms of the same element / with same proton (atomic) number / same number of protons (1)
different numbers of neutrons / nucleon number / mass number (1) [2]

(b)

isotope	no. of protons	no. of neutrons	no. of electrons
^{24}Mg	12	12	12
^{26}Mg	12	14	12

each correct row (1) [2]

(c) $A_r = \frac{24 \times 78.60 + 25 \times 10.11 + 26 \times 11.29}{100} \quad (1)$

$$= \frac{1886.40 + 252.75 + 293.54}{100}$$

gives 24.33 to 4 sig fig (same as data in question)

do not credit wrong number of sig figs **or** incorrect rounding up/down (1) [2]



(e) (i) $n(\text{Sb}) = \frac{2.45}{122} = 0.020 \quad (1)$

(ii) mass of Cl in **A** = $4.57 - 2.45 = 2.12 \text{ g} \quad (1)$

$$n(\text{Cl}) = \frac{4.57 - 2.45}{35.5} = \frac{2.12}{35.5} = 0.06$$

allow ecf as appropriate (1)

(iii) $\text{Sb} : \text{Cl} = 0.02 : 0.06 = 1:3$
empirical formula of **A** is $\text{SbCl}_3 \quad (1)$



(f) (i) ionic (1)

(ii) covalent (1)
not van der Waals' forces [2]

[Total: 14]

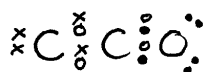
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- 2 (a) 1 $S + O_2 \rightarrow SO_2$ (1)
- 2 $2SO_2 + O_2 \rightleftharpoons 2SO_3$ equation (1)
equilibrium sign (1)
- 3 $SO_3 + H_2O \rightarrow H_2SO_4$ **or**
 $SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$ (1) [4]
- (b) condition 1 400 – 600 °C (650 – 900K) (1)
condition 2 1–10 atm/just above atmospheric pressure
allow equivalent pressure units (1)
condition 3 vanadium pentoxide/vanadium(V) oxide/ V_2O_5 (1) [3]
- (c) fertilisers/phosphates/ammonium sulfate **or**
lead/acid batteries **or** paints/pigments **or** dyestuffs **or**
steel pickling **or** metal treatment **or** detergents **or** explosives (1) [1]
- (d) (i) $2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$ (1)
- (ii) H_2S –2 SO_2 +4 S 0 **all three** (1)
 SO_2 **because** the oxidation number of S is reduced (1) [3]
- (e) (i) $2NO + O_2 \rightarrow 2NO_2$ (1)
 $SO_2 + NO_2 \rightarrow SO_3 + NO$ (1)
 $SO_3 + H_2O \rightarrow H_2SO_4$
final product must be H_2SO_4 (1)
- (ii) corrosion of buildings **or**
dissolving of Al^{3+} ions from soil **or**
pollution of rivers/killing aquatic life **or**
making soil acidic/killing trees/corrosion of metals (1) [4]
- (f) it is a reducing agent/inhibits oxidation (1) [1]

[Total: 16]

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- 3 (a) (i) order of atoms **must** be C-C-O

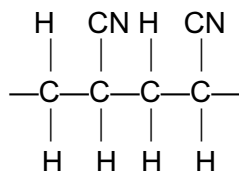


(1)

linear (1)

- (ii) a molecule or atom with an unpaired electron **or**
a species formed by the homolytic fission of a covalent bond (1)
- (iii) molecule has 2 bond pairs and one lone pair (1)
and one unpaired electron (1)
these may be shown in a diagram [5]

- (b) (i)



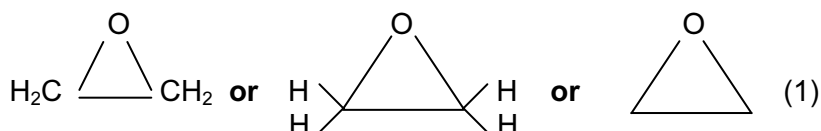
allow the structural formula $-\text{CH}_2\text{CH}(\text{CN})\text{CH}_2\text{CH}(\text{CN})-$ (1)

- (ii) addition (1)

[2]

- (c) (i) CH_3CHO (1)

- (ii)



[2]

- (d)

reagent	product
Br_2 in an inert solvent	$\text{BrCH}_2\text{CHBrCHO}$
$\text{NaCN} + \text{dil. H}_2\text{SO}_4$	$\text{CH}_2=\text{CHCH}(\text{OH})\text{CN}$ allow $\text{CH}_2=\text{CHCH}(\text{OH})\text{CO}_2\text{H}$
Tollens' reagent	$\text{CH}_2=\text{CHCO}_2\text{H}$ or $\text{CH}_2=\text{CHCO}_2^-$
NaBH_4	$\text{CH}_2=\text{CHCH}_2\text{OH}$

(4 × 1)

[4]

[Total: 13]

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4 (a) $C : H : Br = \frac{29.3}{12} : \frac{5.7}{1} : \frac{65.0}{79.9} \quad (1)$
 $= 2.44 : 5.7 : 0.81$
 $= 3 : 7 : 1 \quad (1)$

$C_3H_7Br = (3 \times 12) + (7 \times 1) + 79.9 = 122.9$

use of 122.9 or 123 to prove

molecular formula must be C_3H_7Br (1)

[3]

(b) (i) mechanism must be S_N2

dipole on C-Br bond **or**

central C atom shown with δ^+ (1)

attack on C atom by lone pair of OH^-

not from negative charge (1)

transition state formed **with** negative charge shown (1)

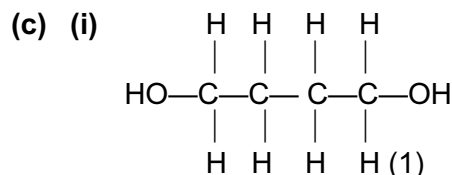
Br^- leaves/ $NaBr$ formed (1)

(ii) C_2H_4 /ethane (1)

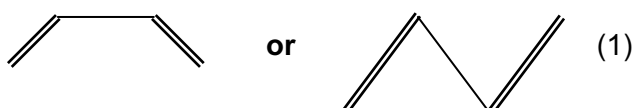
(iii) ethanol/ C_2H_5OH (1)

(iv) elimination (1)

[7]



(ii) **must** be skeletal



[2]

[Total: 12]

5 (a) $AgCl$ /silver chloride (1)

[1]

(b) white (1)

[1]

(c) 1-iodobutane (1)

[1]

(d) C-I bond is weaker/longer than the other C-halogen bonds (1)

C-I bond energy is 240 kJ mol^{-1}

or covalent radius of I is 0.133 nm (1)

[2]

[Total: 5]