

MARKSCHEME

November 2000

CHEMISTRY

Standard Level

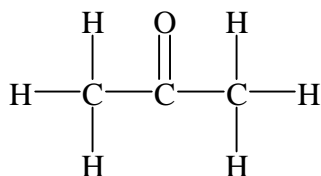
Paper 3

OPTION A – HIGHER ORGANIC CHEMISTRY

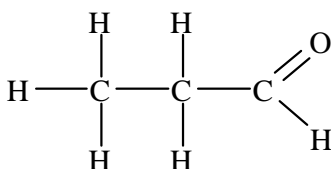
A1. (Give [1] for each correct structure and [1] for correct reasoning for each structure.)

The infra-red absorption at 1700 cm^{-1} indicates $\text{C}=\text{O}$; as **A** cannot be oxidised it must be the alkanone / as **B** is oxidised it must be the alkanal. [2]

Compound **A**

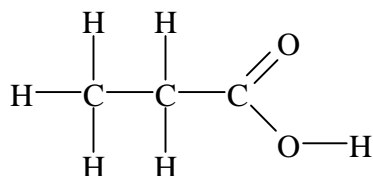


Compound **B**



C (is formed by oxidation of the alkanal **B** and has acidic properties so) must be an alkanolic acid. [1]

Compound **C**



The infra-red data ($3230\text{--}3550\text{ cm}^{-1}$) indicates $\text{O}-\text{H}$ bond;

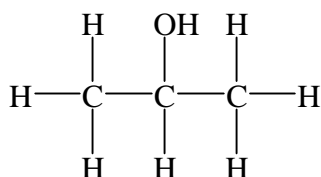
M_r value of 60 indicates that **D** and **E** are both alkanols with formula $\text{C}_3\text{H}_8\text{O}$.

D must be a secondary alkanol as it is formed by reduction of **A**, an alkanone;

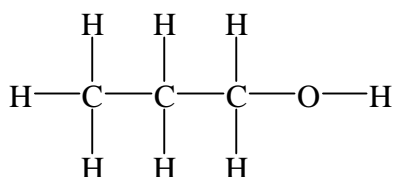
E must be a primary alkanol as it is formed from reducing **B**, an alkanal.

(any two for [2])

Compound **D**



Compound **E**



A2. (a) (i) Linear **OR** $\text{H}-\text{C}\equiv\text{N}$ *[1]*

(ii) Trigonal planar **OR** $\begin{array}{c} \text{H} \\ \diagdown \\ \text{C}=\text{O} \\ \diagup \\ \text{H} \end{array}$ *[1]*

(iii) Tetrahedral **OR** $\begin{array}{c} \text{H} \\ | \\ \text{C} \\ / \quad | \quad \backslash \\ \text{Cl} \quad \text{H} \quad \text{Cl} \end{array}$ *[1]*

(b) (i) Six *[1]*

(ii) Octahedral **OR** $\left[\begin{array}{c} \text{Cl} \\ \vdots \\ \text{Cl} \quad \text{Si} \quad \text{Cl} \\ \vdots \\ \text{Cl} \end{array} \right]^{2-}$ *[1]*

OPTION B – HIGHER PHYSICAL CHEMISTRY



(b) $K_a = \frac{[\text{C}_2\text{H}_5\text{COO}^-] \times [\text{H}^+]}{[\text{C}_2\text{H}_5\text{COOH}]}$ [1]

$K_a = 1.35 \times 10^{-5} \text{ mol dm}^{-3}$ (units not necessary for mark) [1]

(c) $1.35 \times 10^{-5} = \frac{[\text{H}^+]^2}{0.01}$ [1]

$[\text{H}^+] = \sqrt{1.35 \times 10^{-5} \times 0.01} = 3.67 \times 10^{-4} \text{ mol dm}^{-3}$ [1]

(d) For NaOH, $n = 0.01 \times \frac{200}{1000} = 0.002 \text{ mol}$

For acid, $n = 0.01 \times \frac{300}{1000} = 0.003 \text{ mol}$

After reaction, $n = 0.003 - 0.002 = 0.001 \text{ mole of acid remaining.}$ [1]

$[\text{C}_2\text{H}_5\text{COO}^-] = 0.004 \text{ mol dm}^{-3}, [\text{C}_2\text{H}_5\text{COOH}] = 0.002 \text{ mol dm}^{-3}$ [1]

$[\text{H}^+] = 1.35 \times 10^{-5} \times \frac{0.002}{0.004} = 6.75 \times 10^{-6}$ [1]

$\text{pH} = -\log_{10}[\text{H}^+] = 5.17$ [1]

B2. (a) The value is positive as a solid is forming a gas which is more disordered. [1]

(b) $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$ [1]

$= 178 - \left[298 \times \frac{161}{1000} \right] = +130 \text{ kJ mol}^{-1}$ [1]

(c) In a spontaneous reaction the total entropy of a system and its surroundings increases. (Accept that for a spontaneous reaction ΔG must be less than zero.) [1]

(d) For the reaction to become spontaneous $\Delta H^\circ - T\Delta S^\circ < 0$. [1]

$T = \frac{\Delta H^\circ}{\Delta S^\circ} = \frac{178 \times 10^3}{161} > 1106 \text{ K (833 } ^\circ\text{C)}$ [1]

OPTION C – HUMAN BIOCHEMISTRY

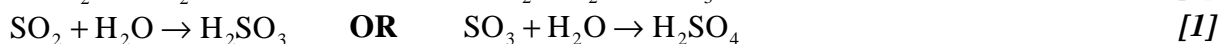
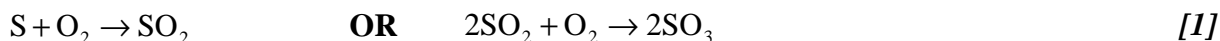
- C1.** (a) Retinol will contain an —OH (alkanol) group (*[1]*).
Retinal will contain a —CHO (alkanal) group (*[1]*).
(If both alkanol and alkanal are given but no structures, award *[1]*) *[2]*
- (b) **Two pairs of electrons (four electrons)** between the two carbon atoms. *[1]*
- (c) M_r for retinol = $(19 \times 12.01) + (30 \times 1.01) + (1 \times 16.00) = 274.5$ *[1]*
Concentration is 0.30 g dm^{-3} which is $1.1 \times 10^{-3} \text{ mol dm}^{-3}$. *[1]*
(accept $1.09 \times 10^{-3} \text{ mol dm}^{-3}$)
- (d) More fat soluble. *[1]*
Because the polar O—H bond will be insignificant compared to the bulky non-polar ‘tail’ of the molecule. *[1]*
- OR** Because there is a very low concentration (of retinol in the blood).
- OR** Non-polar hydrophobic chain will be more soluble in fat than polar water.
- C2.** (a) Iodine. *[1]*
- (b) Any *two* from: acid, —COOH; amine, —NH₂; alkoxyalkane (ether), —O—; *[4]*
(do not accept amide for —NH₂)
- (Give *[1]* for each correct name and *[1]* for each correct formula. Award no marks for C₆H₅ – phenyl.)
- (c) Hormones are chemical messengers **OR** substances that regulate bodily processes such as growth and metabolism. *[1]*
Hormones are transported by the blood stream. *[1]*
- (d) Thyroxine regulates the rate at which cells use oxygen **OR** controls the rate of carbohydrate metabolism **OR** controls the rate of protein synthesis and breakdown **OR** stimulates energy production in cells. *[1]*

OPTION D – ENVIRONMENTAL CHEMISTRY

D1. (a) 1000:1 (*do not accept 1:1000*) [1]

(b) Sulfuric acid (accept sulfuric(IV) acid or sulfurous acid). [1]

(*No mark if just the formula is given.*)



(c) Nitric acid (accept nitrous acid or nitric(III) acid). [1]

(*Award [1 mark] each for any two different ways, for example:*)

- Use a catalytic converter;
- use a richer petrol:air mixture;
- car sharing;
- switching to a different fuel such as solar power or electricity *etc*;
- thermal exhaust system;
- increase the use of public transport;
- switch to a car with a ‘lean-burn’ engine. [2]

(d) $CaCO_3 + 2H^+ \rightarrow Ca^{2+} + CO_2 + H_2O$ (accept H_2CO_3). [1]

(*Accept the full equation with either nitric or sulfuric acid.*)

D2. (a) (i) As the temperature increases the solubility of oxygen decreases. [1]

(ii) As organic pollutants decompose they use up available oxygen so the amount of dissolved oxygen decreases. [1]

(iii) Nitrates and phosphates act as nutrients and increase the growth of algae. As the algae die they use up dissolved oxygen (eutrophication). [1]

(b) The BOD is the quantity of oxygen (in ppm) utilised when the organic matter in a fixed volume of water is decomposed biologically over a set time period (usually five days). [1]

(c) Amount of $Na_2S_2O_3$ in 10 cm^3 of 0.100 mol dm^{-3} $Na_2S_2O_3$ is $\frac{10}{1000} \times 0.100 = 1.00 \times 10^{-3}$ moles. [1]

One mole of O_2 reacts to give two moles of MnO_2 which give two moles of I_2 which react with four moles of $S_2O_3^{2-}$ so that the amount of oxygen present in 1000 cm^3 is $\frac{1}{4} \times 1.00 \times 10^{-3} = 2.50 \times 10^{-4}$ moles. [1]

Mass of 2.50×10^{-4} moles of O_2 is $32 \times 2.50 \times 10^{-4} = 8.00 \times 10^{-3}$ g.
Concentration of dissolved oxygen is $8.00 \times 10^{-3}\text{ g dm}^{-3}$ (or 8 mg dm^{-3}). [1]

OPTION E – CHEMICAL INDUSTRIES

- E1.** (a) (i) Carbon. [1]
- (ii) Contains higher percentage of iron. [1]
- (b) (i) Oxygen and powdered lime (calcium oxide / calcium carbonate). [2]
(do not accept metals such as chromium)
- (ii) The impurities are oxidised **OR** oxidation takes place. [1]
The oxidised impurities combine with the lime to form slag **OR** an acid–base reaction takes place (accept equation). [1]
- (c) It is more expensive to produce aluminium from its ores as it requires more energy (even though Al is more abundant in the earth’s crust than Fe). [1]
- E2.** (a) Crude oil was formed from marine organisms which contained sulfur (in their amino acids). [1]
- (b) Sulfur can poison many of the catalysts used in the refining processes (by reacting irreversibly with their reactive sites). [1]
OR When the oil is burned SO_2 is produced which leads to acid rain.
- (c) $\text{C}_{10}\text{H}_{22} \rightarrow \text{C}_8\text{H}_{18} + \text{C}_2\text{H}_4$ (accept other balanced combinations of an alkane and an alkene). [1]
Larger molecules are broken down into smaller more useful molecules (the alkane is used as gasoline and the alkene as feedstock for polymers). [1]
- (d) Isomerisation involves **rearrangement** to form another isomer. [1]
Alkylation involves the **combination** of alkanes and alkene (to form higher-grade gasolines). [1]
- (e) (i) $\text{C}_6\text{H}_{14} \rightarrow \text{C}_6\text{H}_6 + 4\text{H}_2$ [1]
- (ii) Haber process (manufacture of ammonia). [1]

OPTION F – FUELS AND ENERGY

F1. (a) Methane / CH_4 . [1]

(b) Carbon monoxide **OR** hydrogen. (*accept correct formulas*) [1]

(c) Any **two** from:
 • particulates (soot);
 • C_xH_y (accept HC or hydrocarbons);
 • CO (do not accept SO_x or NO_x). [2]

(d) Biomass is produced (continuously) from waste products or quick growing crops, therefore there is no need to use foreign exchange to import oil or other fuels. [1]

OR Because fossil fuels are running out / biomass is obtained from recyclable materials.

F2. (a) Splitting of an (unstable) nucleus. [1]

(b) There is a small mass loss which is converted into a large amount of energy. [1]

(c)

X	n	b	1
Y	Pu	c	0
Z	e	d	0
a	92	e	–1

[4]

(Award [1/2] for each, round **down**.)

(d) To prevent radioactivity from escaping. [1]

Closed loop primary coolant: water, heavy water, sodium, CO_2 . [1]

(e) $\frac{1.2 \times 10^{-12}}{1.5 \times 10^{-13}} = 8 = 2^n$ therefore number of half-lives (n) is 3. [1]

Age of object is $3 \times 5730 = 1.7 \times 10^4$ years (17 190 years). [1]