M99/420/S(3)M

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MARKSCHEME

May 1999

CHEMISTRY

Standard Level

Paper 3

14 pages

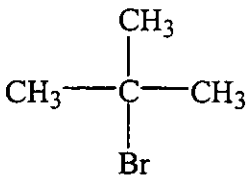
OPTION A – HIGHER ORGANIC CHEMISTRY

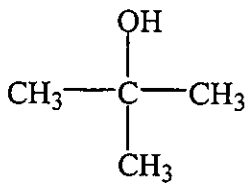
A1. (a) C_2H_2 linear
CH_3Cl tetrahedral
accept diagram of CH_3Cl if 3-dimensional
CH_3^+ planar/trigonal
accept diagrams for C_2H_2 / CH_3^+ if correct angles given
[1 mark]** for **each** shape. **[1 mark]** for explanation* ***[4 marks]

(b) Acid: C=O bond shorter/C–O longer ***[1 mark]***

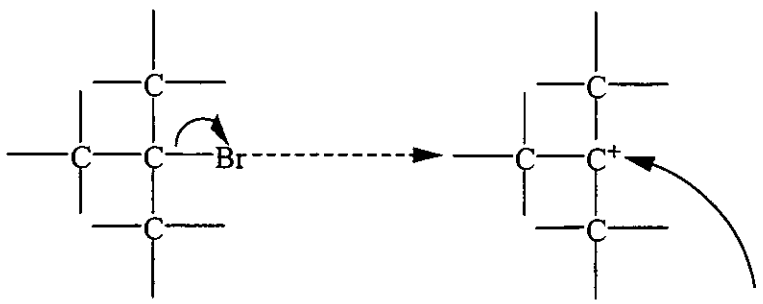
Ion: C–oxygen bonds are not double and single/in between *etc.* ***[1 mark]***
some explanation (*e.g.* resonance) / delocalisation / diagrammatic
e.g. $\overline{----}$ ***[1 mark]***

A2. (a) Correct structural formula of A ***[1 mark]***
Correct structural formula of B ***[1 mark]***


A


B

***[1 mark]** if A and B are wrong but OH replaced Br)*



*Step 1: **[1 mark]**. Accept breaking of C–Br bond to give carbonium ion.*
*Step 2: arrow **[1 mark]**, nucleophile **[1 mark]**.*
Accept arrow from any part of the nucleophile (OH^-).

If S_N2 offered, could score ***[2 marks]*** *e.g.* correct nucleophile(OH^-) and arrow from Nu to electron deficient carbon. ***[3 marks]***

(b) lower $[H^+]$/weakly (partially) ionised/dissociated into $[H^+]$ ***[1 mark]***

Introduction of C=O increases polarity/weakens O–H bond ***[1 mark]***
$CH_3CO_2^-$ more stable than $CH_3CH_2O^-$ (delocalisation) ***[1 mark]***

OPTION B – HIGHER PHYSICAL CHEMISTRY

B1. (a) $CH_3CH_2COOH + H_2O \rightleftharpoons CH_3CH_2COO^- + H_3O^+$ ⇌essential

OR $CH_3CH_2COOH \rightleftharpoons CH_3CH_2COO^- + H^+$ *[1 mark]*

(b) $K_a = \dfrac{[CH_3CH_2COO^-][H_3O^+]}{[CH_3CH_2COOH]}$

accept $[H^+]$ instead of $[H_3O^+]$ *[1 mark]*

(c) (i) $pK_a = 4.87$ *[1 mark]*

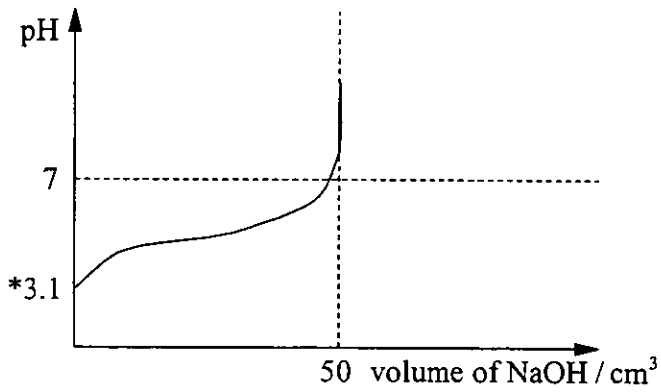
(ii) $[CH_3CH_2COO^-] = [H_3O^+] = x$ **OR** $K_a = \dfrac{x^2}{0.05 - x} \sim \dfrac{x^2}{0.05}$ *[1 mark]*

$x = \sqrt{0.05 \times 1.34 \times 10^{-5}} = 8.19 \times 10^{-4}$ *[1 mark]*

$pH = -\log[H_3O^+] = 3.1$ (accept 3.0) *[1 mark]*

*correct answer scores **[3 marks]***

(d)



Correct initial pH (*consequential on (c)(ii)) *[1 mark]*
Curve between initial pH and equivalence point (some 'relatively flat' portion) *[1 mark]*
Correct volume of NaOH at equivalence point *[1 mark]*
Vertical region **must** start at pH > 7 *[1 mark]*

B2. (a) $\Delta S^\circ = \sum S^\circ_{products} - \sum S^\circ_{reactants}$ ***[1 mark]***

$S^\circ CH_4 = 186\ J\ K^{-1}\ mol^{-1}$ from data booklet ***[1 mark]***

$\Delta S^\circ = 186\ J\ K^{-1}\ mol^{-1} - (5.73\ J\ K^{-1}\ mol^{-1} + 2 \times 130.6\ J\ K^{-1}\ mol^{-1})$ ***[1 mark]***

$\Delta S^\circ = -80.93\ J\ K^{-1}\ mol^{-1}$ ***[1 mark]***

*award **[3 marks]** for correct answer only, i.e. no working.*
ignore absence of units but penalise incorrect units.
** incorrect info taken from Data Booklet **could** score first and last two marks. However, if 186 appears anywhere in the calculation award **[1 mark]** for the correct use of the Data Booklet.*

(b) Entropy of products is lower than entropy of reactants.
/There is one gaseous mol in products and two gaseous mol in reactants, so molecular disorder decreases. (Decrease in entropy – reduction in number of moles of gas.)

N.B. consequential upon (a) ***[1 mark]***

OPTION C – HUMAN BIOCHEMISTRY

C1. (a) Coconut oil *[1 mark]*
The more unsaturated the oil, the bigger the iodine index (or the converse). *[1 mark]*

(b) M_R of oleic acid: $[(18\times12.0)+34.0+(16.0\times2)]=282.0$ *[1 mark]*
M_R of iodine: $126.9\times2=253.8$ *[1 mark]*
Note: possibility of error carried forward

$$\text{Iodine Index}=\frac{100.0\times253.8}{282.0}=90$$ *[1 mark]*

(c) Olive oil *[1 mark]*
highest degree of unsaturation/**most** unsaturated/**highest** iodine index *[1 mark]*

(d) In order to maintain body temperature/prevent skindrying (waterproofing) *[1 mark]*
Energy source *[1 mark]*
Cell membranes *[1 mark]*
Protect organs
Carry fat-soluble vitamins

C2. (a) Organic micronutrients that the body cannot produce in amounts needed for good health / an organic compound necessary to a healthy life that humans cannot synthesise (but must obtain in the diet).
Note: **essential** part of the diet *[1 mark]* implies inadequate production in the body

*[For the mark, candidates must indicate any **two** of the following:* *[1 mark]*
the vitamin is organic, is required for good health, and it is not made in adequate quantities in the human body.]

(b) *[1 mark] for each correct **pairing**:*

Poor night vision	Vitamin A
Beriberi	Vitamin B_1/B
Dermatitis	Vitamin B, C, niacin
Scurvy	Vitamin C
Rickets	Vitamin D
Sterility	Vitamin E
Muscular dystrophy	Vitamin E
Pellagra	niacin/vitamin B

Look for specific conditions not generalities e.g. vitamin C do not accept colds/'flu *[2 marks]*

(c) Vitamin C is polar/H-bonds / vitamin A is non-polar / C more polar than A *[1 mark]*
consequence of polarity –OH groups / explanation of non-polarity *[1 mark]*
If only one vitamin is discussed, award *[1 mark]* out of 2.

OPTION D – ENVIRONMENTAL CHEMISTRY

D1. (a) Carbon dioxide (dissolving/reacting with water) ***[1 mark]*** only
No mark for CO_2 alone

[2 marks]

$CO_2(aq) + H_2O \rightleftharpoons H_2CO_3(aq)$ + solution is acidic

OR

$CO_2 + H_2O \rightleftharpoons H^+(aq) + HCO_3^-(aq)$ + H^+implies it is acidic

(b) HNO_3 ***[1 mark]***
H_2SO_4 / H_2SO_3 ***[1 mark]***
NO – automobiles ***[1 mark]***
(Subsequent reaction of the NO with oxygen to produce NO_2 and reaction of NO_2 with water.)
SO_2 – smelters/smelting/ burning coal or oil/volcanoes ***[1 mark]***

equation for production of acid ***[1 mark]***

(c) Leaching minerals from the soil
Fishless lakes
Damaging stone buildings
Damaging trees / forests
Iron/steel objects rust more quickly

*any two **[1 mark]** (accept valid alternatives)* ***[1 mark]***

D2. (a) $O_2 + h\nu \rightarrow 2O$
$O + O_2 \rightarrow O_3$

each** equation scores **[1 mark]

[1 mark]** for $h\nu$ radiation* ***[3 marks]

(b) increase in incidence of **skin** cancer / genetic damage to animals / plants / satellite imaging / weather balloon **data** / ozone hole over Antarctic
Any two ***[2 marks]***

(c) Chlorine **atoms** generated from the CFCs act as **catalysts** in the decomposition of ozone. One chlorine atom can destroy many molecules of O_3, as it is **regenerated** many times / description of catalytic behaviour. ***[2 marks]***

In absence of any other credit, mention of CFCs (not aerosols) ***[1 mark]***

OPTION E – CHEMICAL INDUSTRIES

E1. (a) (i) The electrolysis can be carried out at a much lower temperature/ cryolite lowers melting point of alumina *[1 mark]*

(ii) $2O^{2-} - 4e^- \rightarrow O_2$ /half version $O^{2-} - 2e^- \rightarrow \frac{1}{2}O_2$ *[1 mark]*

(iii) Oxygen (produced at the anode) reacts with the carbon electrode/ Carbon (anode) burns in O_2 formed / $C + O_2 \rightarrow CO_2$ *[1 mark]*

(b) Alumina reacts with/dissolves in NaOH/KOH. *[1 mark]*
Basic impurities do not dissolve/alumina acts as an acidic oxide. *[1 mark]*

(c) Aluminium is lighter/less dense than copper (and so the pylons do not have to be as strong). *[1 mark]*

E2. (a) Named hydrocarbon *e.g.* propane *[1 mark]*

balanced equation (*e.g.* $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$) N.B. **complete** combustion *[1 mark]*

(b) Balanced equation showing production of appropriate alkane and alkene (*e.g.* $C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$) *[2 marks]*

An unbalanced equation showing the formation of an alkane **and** an alkene *[1 mark]*

(c) Stage 1: **Fractional distillation** *[1 mark]*
Stage 2: Ethene is produced by **cracking** less valuable fractions *[1 mark]*
Stage 3: **Polymerisation** is used to convert ethene into polythene *[1 mark]*

(d) Toxic substances associated with combustion of plastics
Problems disposing of non-biodegradeable plastics *[2 marks]*
Build up of (plastic) litter

accept other valid answers

OPTION F – FUELS AND ENERGY

F1. (a) $\frac{1000}{12} = 83.3$ mol carbon *[1 mark]*

heat (evolved) = moles $\times (-\Delta H_c^\theta)$
$= 83.3 \times (-393.5)$
$= 32.8$ MJ (32 800 KJ) (second mark consequential on above) *[1 mark]*

(b) $2C(s) + O_2(g) \rightarrow 2CO(g)$/
$S(s) + O_2(g) \rightarrow SO_2(g)$

not *$NO_2(g)$*
State symbols **not** required
Symbol for sulphur could be S_x (x = 1 to 8) *[1 mark]*

(c) CO ensure efficient/complete combustion/ensuring excess air/O_2

SO_2 (scrubbing the gas) by passing through an alkali/absorb in slurry of powdered limestone in water
desulphurisation (of the fuel)
don't burn it/switch to an alternative fuel

not just scrubbing/limestone

NO_2 *if given in B* – (scrubbing the gas) by passing through an alkali

not just scrubbing

any one, ***[1 mark]*** *[1 mark]*

(d) Water/steam *[1 mark]*

$C(s) + H_2O(g) \rightarrow H_2(g) + CO(g)$ *[1 mark]*

state symbols not essential

(e) easy to burn/easy to mix with air/controlled rate of combustion
easy to transport/(by tanker or pipeline)/easy to handle/can be pumped

[2 marks]

F2. (a) Rearrangement of extranuclear/outer electrons as compared with nuclear processes/emphasis on the change in the nucleus/no new 'elements' or atoms formed (chemical reaction) or converse re nuclear reaction or lower energy change (chemical)/no mass loss (chemical)/no change in the nucleus (chemical) ***[1 mark]***

N.B. sequence in question chemical–nuclear may be implicit to the answer/assume if statement restricted to chemical, the opposite applies to nuclear

(b)

shielding	–	to prevent escape of nuclear particles/radioactivity
control rods	–	to control and maintain a safe level of fission/control number of free neutrons
cooling system	–	maintain temperature of reactor (core)
moderator	–	to slow the **neutrons**

[2 marks] *each* ***[6 marks]***

In the **absence** of **any** role being assigned give *2 marks* for three components (*1 mark* for two components). These are salvage marks only.