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MARKSCHEME

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CHEMISTRY

Standard Level

Paper 3

13 pages

OPTION A – HIGHER ORGANIC CHEMISTRY

A1. (a)

Molecule	Number of pairs of electrons around the central (underlined) atom	Shape of molecule
$\underline{B}Cl_3$	**3**	**trigonal planar**
H_2S	**4**	**bent/V-shaped/angular**

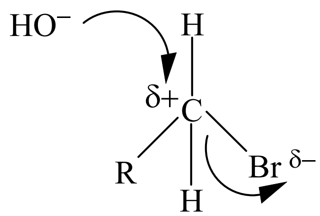
*(Give **[3]** for 4 correct, **[2]** for 3 correct, **[1]** for 2 correct)* ***[3]***

(b) (i) Double and triple bonds each count as one charge centre/pair of electrons ***[1]***

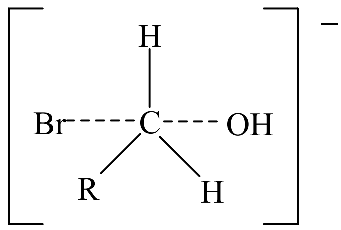
(ii) HCN linear ***[1]***
XeF_4 square planar ***[1]***
SO_3^{2-} trigonal pyramid ***[1]***

Total [7]

A2. (a) (i) S_N2 / substitution nucleophilic bimolecular ***[1]***



[1]



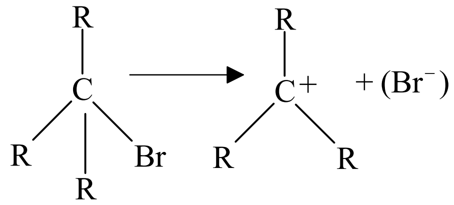
[1]

Insist on negative charge (–) and dotted or longer bonds between C and Br and C and OH ***[2]***

continued...

Question A2 (a) continued

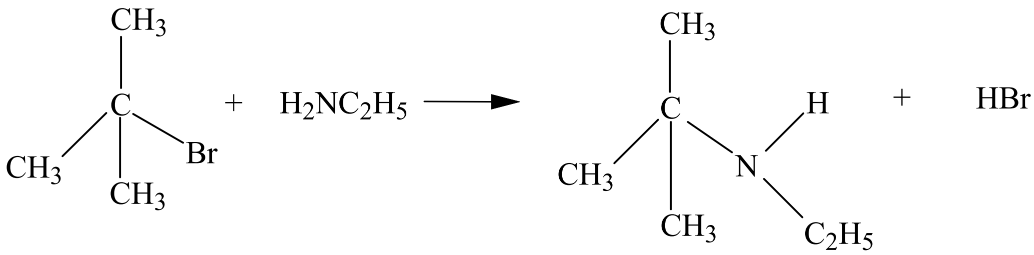
(ii) S_N1 / substitution nucleophilic unimolecular **[1]**



$R_3C^+ + OH^- \rightarrow R_3COH$

[1] ***[1]*** ***[2]***

(b) $(CH_3)_3CBr$ / 2-bromo-2-methylpropane will react faster as it is a tertiary halogenoalkane/S_N1 reacts faster than S_N2 (*must have reason for mark*) ***[1]***



[1]

(accept use of molecular formulas in balanced equation)

Total [8]

OPTION B – HIGHER PHYSICAL CHEMISTRY

B1. (a) (i) It is positive *[1]*
Gas + solid on right hand side / particles further apart is more disordered than solid on left hand side *[1]*

(ii) $\Delta G^{\ominus} = \Delta H^{\ominus} - \mathrm{T}\Delta S^{\ominus}$ *[1]*

$$= 100.3 - \frac{298 \times 174.8}{1000} = +48.2 \text{kJ mol}^{-1}$$ *[1]*

(iii) Not spontaneous (*if value above given as negative accept spontaneous*) *[1]*
574K (301°C) *[1]*

(b) They need to overcome the activation energy *[1]*

Total [7]

B2. (a) (i) First order *[1]*

(ii) Second order *[1]*

(iii) rate $= \mathrm{k}[\mathrm{H_2(g)}][\mathrm{NO(g)}]^2$ (*states not necessary for mark*) *[1]*

(iv) 8.33×10^4 ***[1]*** $\mathrm{dm^6\ mol^{-2}\ s^{-1}}$ ***[1]*** *(allow for ECF)* ***[2]***

(b) (i) rate $= 8.33 \times 10^4 \times (5.00 \times 10^{-3})^3 = 1.04 \times 10^{-2} \mathrm{mol\ dm^{-3}\ s^{-1}}$ (*allow for ECF*) *[1]*

(ii) Step 2 is the slow step *[1]*
The rate depends on $[\mathrm{H_2}]$ and $[\mathrm{N_2O_2}]$ which in turn depends on $[\mathrm{H_2}][\mathrm{NO}]^2$ /
$[\mathrm{H_2}]$ is in the rate equation but does not appear in Step 1. *[1]*

Total [8]

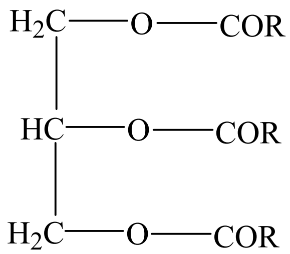
OPTION C – HUMAN BIOCHEMISTRY

C1. (a) $\Delta H = \text{ms}\Delta T$ (or implied) ***[1]***

$= 10.0 \times 4.18 \times 45.2 = 1890$ J (1.89 kJ) ***[1]***

(b) 1.89 kJ given out when (2.063 – 1.568) g burned

enthalpy of combustion per gram $= \dfrac{1.89}{0.495} = 3.82 \text{ kJ g}^{-1}$ ***[1]***

(c)  (***[1]*** *for glycerol skeleton*, ***[2]*** *if all correct*) ***[2]***

(d) (*Any two of the following* ***[1]*** *each*:)

The peanut was not pure peanut oil
Some of the heat given out when the peanut was burned was lost to the surroundings
Complete combustion assumed
Loss in mass of peanut only due to combustible material ***[2]***

(e) (*Any two of the following* ***[1]*** *each*:)

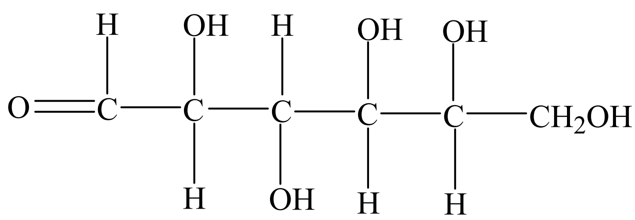
Use peanut oil instead of a peanut
Use a calorimeter instead of a test tube/include heat content of calorimeter
Burn peanut in oxygen not air
Insulate the calorimeter *etc.* ***[2]***

Total [9]

C2. (a) Empirical formula CH_2O (*accept* $(CH_2O)_n$) ***[1]***

Contain a carbonyl / C=O group. ***[1]***

Contain at least two hydroxyl / –OH groups. ***[1]***

(b)  ***[1]***

(c) Heat from 1.00 g $= \dfrac{2816}{180} = 15.6 \text{ kJ g}^{-1}$ (*accept 15.6 kJ*) ***[1]***

(d) Sugars are already partially oxidised compared to the long hydrocarbon chains in oils. ***[1]***

Total [6]

OPTION D – ENVIRONMENTAL CHEMISTRY

D1. (*Any two of the following,* ***[1]*** *each*)

(a) Earth's mean temperature has increased / climate change / polar ice caps melting / sea levels rising ***[2]***

(b) Methane / CH_4 / water / H_2O / nitrogen oxides / NO_x / O_3 / CFCs ***[1]***

(c) High energy/short wavelength radiation passes through the atmosphere containing CO_2 ***[1]***
Lower energy/longer wavelength radiated from the Earth's surface ***[1]***
Radiation absorbed by (vibrating bonds in) carbon dioxide molecules ***[1]***

(d) Reflect incoming radiation (so prevent Earth's surface from warming) ***[1]***

Total [7]

D2. (a) Much energy required to break strong bonds (triple in N_2 and double in O_2) / high activation energy. ***[1]***

(b) (i) Rhodium / platinum / palladium ***[1]***

(ii) $2NO + \underbrace{2CO}_{[1]} \rightarrow \underbrace{N_2 + 2CO_2}_{[1]}$ ***[2]***

(If equation not correctly balanced award ***[1]*** *only.)*

(iii) Lean burn engine / recirculation of gases ***[1]***
Lower O_2 to fuel ratio ***[1]***

(c) (i) Sulfur dioxide / SO_2 ***[1]***

(ii) $CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + CO_2 + H_2O$ ***[1]***
(*accept* $CO_3^{2-} + 2H^+ \rightarrow CO_2 + H_2O$)

Total [8]

OPTION E – CHEMICAL INDUSTRIES

E1. (a) (i) Sulfur in FeS_2 would be converted to SO_2 which could cause acid rain. ***[1]***

(ii) Pellets have a large surface area, which increases the reaction rate. ***[1]***

(b) (i) $C + O_2 \rightarrow CO_2$ ***[1]***

(ii) $C + CO_2 \rightarrow 2CO$ ***[1]***

(iii) $Fe_3O_4 + 4CO \rightarrow 3Fe + 4CO_2$ ***[1]***

(c) (i) Silicon dioxide / SiO_2 ***[1]*** and aluminum oxide / Al_2O_3 ***[1]*** ***[2]***
(*accept other non-metal oxides*)

(ii) $CaCO_3 \rightarrow CaO + CO_2$ ***[1]***

(iii) $SiO_2 + CaO \rightarrow CaSiO_3$ / $SiO_2 + CaCO_3 \rightarrow CaSiO_3 + CO_2$ /
$Al_2O_3 + CaO \rightarrow Ca(AlO_2)_2$ ***[1]***

(iv) Road making/cement ***[1]***

Total [10]

E2. (a) (i) Lower the melting point ***[1]*** and make the iron brittle ***[1]***. ***[2]***

(ii) Oxygen is blown into/onto the iron to burn off impurities. ***[1]***

(b) Cr/Ni ***[1]*** is added to prevent rusting ***[1]*** / to make stainless steel to use for cutlery, *etc.* / V ***[1]*** for high speed tools ***[1]*** / Ni ***[1]*** for shock resistance *etc*. ***[1]***.
(Accept a named alloy and its use.) ***[2]***

Total [5]

OPTION F – FUELS AND ENERGY

F1. (a) (i) $C_{18}H_{38} \rightarrow C_8H_{18} + C_{10}H_{20}$ (*or any balanced equation that gives octane and an **alkene***) ***[1]***

(ii) alkenes used to manufacture polymers ***[1]***

(b) $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ ***[1]***

(c) (i) $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O \,/\, C_8H_{18} + 12\tfrac{1}{2}O_2 \rightarrow 8CO_2 + 9H_2O$ ***[1]***
$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ ***[1]***

(ii) 114 g of octane gives 5512 kJ / 5.51×10^3 kJ ***[1]***
1.00 kg of octane gives 48 351 kJ / 4.84×10^4 kJ ***[1]***
(46 g of ethanol gives 1371 kJ) $\Rightarrow$ 1.00 kg of ethanol gives 29 804 kJ / 2.98×10^4 kJ ***[1]***

(iii) Gasoline expensive to import/rely more on home produced fuel/oil running out *etc*. ***[1]***

Total [9]

F2. (*Any two of the following, **[1]** each*)
(a) Cleaner to burn/less pollution
Coal reserves greater than oil/natural gas
Gases and liquid fuels easier to transport through pipelines ***[2]***

(b) (i) Heating coal in the absence/limited supply of air ***[1]***

(ii) Steam ***[1]***; heat ***[1]*** ***[2]***

(iii) Hydrogen ***[1]***

Total [6]